THE IMPACTS OF GLOBAL TRADE AND INVESTMENT LIBERALIZATION ON NON-COMMUNICABLE DISEASE RISK FACTORS

by
Krycia Cowling, MPH

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Abstract

Non-communicable diseases (NCDs) now account for approximately 60% of the global disease burden; leading risk factors for NCDs include poor diet, and tobacco and alcohol use. By facilitating the manufacture, sale, and marketing of tobacco, alcohol, and highly processed foods and beverages worldwide, global trade and investment liberalization are important structural determinants of the global NCD epidemic. This dissertation contributes to the quantitative literature on the impacts of global trade and investment on NCD risk factors with two natural experiments and one critical review. The first analysis compares trends in consumption of tobacco, alcohol, and seven key food groups, between 1980 and 2013, in 21 countries joining the World Trade Organization (WTO) and 26 non-members, weighted using propensity scores. Results suggest that following accession to the WTO, countries experience large immediate increases in fruit and vegetable consumption, and steady gradual increases in tobacco and alcohol consumption. The second analysis assesses changes in sales of processed foods and beverages, between 2002 and 2016, in ten countries joining U.S. free trade agreements (FTAs) compared to 11 matched countries without U.S. FTAs in force. Results indicate that after joining a U.S. FTA, sales of ultra-processed products, processed culinary ingredients, and baby food all increase annually. The third study is a critical review of methodological approaches used in quantitative research on global trade and investment and diet, tobacco, alcohol, and related health outcomes. A review of eight review articles identifies 34 relevant quantitative studies, which are evaluated using a novel quality assessment tool. Important ways to improve this literature are identified and

discussed, international data sources for trade and investment indicators are presented, and key gaps in the literature are identified.

Key findings across the three studies include: trade liberalization can lead to increases in selected NCD risk factors; additional research on trade, investment, and alcohol is warranted; substantial country-specific variation in responses to liberalization requires greater exploration; mechanisms linking trade and investment to changes in NCD risk factors are not well understood; and there is potential for expanded use of natural experiment study designs for these topics. This research supports the importance of investing in additional research on global trade and investment as social determinants of health and promoting national and global policies to ensure trade and investment liberalization do not undermine health policy objectives.

Advisor:

Keshia Pollack Porter, PhD, MPH

Readers:

Daniel Magraw, JD

Elizabeth A. Stuart, PhD

Jon Vernick, JD, MPH

Alternates:

Roni A. Neff, PhD, ScM

Lainie Rutkow, PhD, MPH, JD

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List of Abbreviations

AIC	Akaike information criterion
ATT	average treatment effect on treated units
ATE	average treatment effect
BIC	Bayesian information criterion
BIT	bilateral investment treaty
BMI	body mass index
CEM	coarsened exact matching
CITS	comparative interrupted time-series
CVD	cardiovascular disease
DALY	disability-adjusted life year
DESTA	Design of Trade Agreements
EC	European Community
EU	European Union
FAO	Food and Agriculture Organization
FCTC	Framework Convention on Tobacco Control
FDI	foreign direct investment
FLFP	female labor force participation
FTA	free trade agreement
GATT	General Agreement on Tariffs and Trade
GBM	generalized boosted regression modeling
GDP	gross domestic product
GDPpc	gross domestic product per capita
GHDx	Global Health Data Exchange
GMID	Global Market Information Database
GNI	gross national income
HIA	health impact assessment
IHME	Institute for Health Metrics and Evaluation
IIA	international investment agreement
ILO	International Labor Organization
IMF	International Monetary Fund
IPTW	inverse-probability-of-treatment weight
ISDS	investor-state dispute settlement
LMIC	low- and middle-income country
MDG	Millennium Development Goals
NAFTA	North American Free Trade Agreement
NCD	non-communicable diseases
OECD	Organization for Economic Cooperation and Development
RTA	regional trade agreement
SAP	structural adjustment program
SD	standard deviation
SDG	Sustainable Development Goals
SDH	social determinants of health

SECO	Switzerland State Secretariat for Economic Affairs
SPS	Agreement on Sanitary and Phytosanitary Standards
SSB	sugar-sweetened beverage
TBT	Agreement on Technical Barriers to Trade
TFBC	transnational food and beverage corporation
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
UNPOP	United Nations Population Division
USDA	United States Department of Agriculture
USSR	Union of Soviet Socialist Republics
USTR	Office of the United States Trade Representative
WDI	World Development Indicators
WEO	World Economic Outlook
WHO	World Health Organization
WITS	World Integrated Trade Solution
WPP	World Population Prospects
WTO	World Trade Organization
WUP	World Urbanization Prospects
YLL	years of life lost

Chapter 1: Introduction

Statement of the problem

Growth of non-communicable diseases

Non-communicable diseases (NCDs) now account for the majority of the global disease burden, having substantially escalated over the past two decades, and are projected to continue increasing (1). In 1990, NCDs caused 42.6% of global morbidity and mortality, as measured by disability-adjusted life years (DALYs) lost; by 2015, this contribution had increased to 59.7% (2). The transition from communicable diseases to NCDs as the dominant cause of morbidity and mortality began earlier in high-income countries and has steadily shifted to low- and middle-income countries (LMICs) (3), where the majority of NCD deaths now occur (2). Examining age-standardized NCD mortality rates across major world regions, this is now highest in the Eastern Mediterranean region, followed by Africa, and Southeast Asia, all with much higher rates than in Europe or the Americas (4).

Recognition of the increasing significance of NCDs has generated several recent high-profile global health initiatives, notably the World Health Organization's "25 by 25" target, which aims to reduce preventable deaths due to NCDs by 25% by 2025 (5). The United Nations Sustainable Development Goals (SDGs), adopted in 2015 to guide global development efforts through 2030, also include a specific target on NCDs: "By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being" (Target 3.4) (6). Most recently, NCDs featured prominently during the 2017 World Health Assembly,

with many NCD-related agenda items (7), including preparations for the third High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases, to be held in 2018 (8). This recent attention represents a significant shift from the relative absence of NCDs on the global health agenda as recently as 2000 – exemplified by the omission of any NCD-related targets in the Millennium Development Goals (MDGs), the precursor to the SDGs (9).

Despite new global-level attention to NCDs, funding levels lag far behind those for communicable diseases and are dramatically incommensurate with their contribution to the disease burden. In 2015, NCDs caused 67% of all deaths in LMICs, but were the focus of only 1% of total health funding (from government, philanthropic, and international sources combined) in these countries (10). This need for increased funding and action to combat NCDs was the focus of Michael Bloomberg's 2017 annual letter on philanthropy, wherein he stated, "we must go where the data leads us—and it leads directly to NCDs and injuries" (10). Furthermore, current policy responses and proposals overwhelmingly focus on individual determinants of NCDs, to the neglect of political, social, and economic attributes that underlie trends in behavioral risk factors (11). A recent United Nations Development Program (UNDP) discussion paper highlights this imperative to address the underlying determinants of NCDs (12), which is vital to slow the continued growth of an epidemic the world cannot treat its way out of.

Leading NCDs and risk factors

Four broad groups of NCDs accounted for an estimated 40 percent of total years of life lost (YLLs) worldwide in 2015: cardiovascular diseases (19.2%); neoplasms (cancers) (12.0%); diabetes, urogenital, blood, and endocrine diseases (4.8%); and

chronic respiratory diseases (4.0%) (13). Each of these leading classes of NCDs can in part be causally attributed to one or more of three key modifiable individual risk factors: dietary risks, tobacco use, and harmful alcohol use (14)(15)(16). In 2015, dietary risks were the number one risk factor in terms of global mortality, causing just over one in five deaths worldwide. Tobacco use was the third greatest contributor to global mortality, attributable for 12.8% of deaths. An additional 4.1% of deaths was due to harmful alcohol use. In total, poor diet, tobacco, and alcohol use caused an estimated 21.5 million deaths worldwide in 2015 (13).

When considering the contribution of these risk factors to morbidity as well as mortality – using DALYs as a metric of this combined effect – dietary risks remain the leading cause: attributable for 10.7% of global DALYs lost in 2015. Tobacco use contributed to 6.9% and alcohol use to 3.5% of global DALYs lost in 2015. Together, more than one-fifth of the global disease burden can be attributed to these three risk factors (13).

Risk factor trends and underlying determinants

Mirroring trends in the NCDs they help generate, consumption of nutrient-poor foods and beverages, tobacco, and alcohol have increased steadily over the past several decades (17)(18)(19). For each of these products, total consumption is now growing more rapidly in LMICs than in high-income countries (20)(21)(22). Bangladesh, China, Indonesia, and Russia are among the most significant markets with an increase in the number of smokers over the past decade (18), and Southeast Asia and the Western Pacific were the only major world regions that saw increases in per capita alcohol use between 2005 and 2010 (22). The countries with the largest increases in sugar-sweetened beverage

(SSB) sales between 2010 and 2015 were Saudi Arabia, Georgia, Vietnam, and Chile (23). With regard to dietary changes in particular, a gradual shift from traditional diets higher in plant-based foods to greater consumption of more energy-dense foods high in sugars and animal fats has been deemed the "nutrition transition" (17).

These patterns of increasing consumption are theorized to share certain common underlying determinants: in part, they may be attributable to the processes of globalization. While a range of definitions exist, globalization is generally conceptualized as the strengthening of one or more types of links between countries: social, cultural, economic, environmental, political, and technological (24). The economic aspect of globalization may have the most significant causal relationship to trends in dietary, tobacco, and alcohol consumption: economic integration through trade and investment agreements facilitates the flow of goods, services, and capital across national borders (25).

Trade and investment liberalization may catalyze the introduction of new products; suppress or otherwise affect local agriculture; increase advertising and promotion; lead to new forms of retail, such as supermarkets; and reduce prices because of greater product competition, among other effects (25). By fostering retail environments with greater varieties and volumes of products, sold at lower prices and accompanied by more advertising, consumers are provided greater opportunity to purchase and consume nutrient-poor foods and beverages, tobacco, and alcohol – the "unhealthy commodities" (26)(27). Although these changes in consumption patterns have occurred during an era of substantial liberalization of both trade and investment, more research is needed to characterize the nature and consistency of causal relationships

between these global trends, particularly since these trends may also increase the availability of healthier foods.

Global trade and investment liberalization

Trade and investment liberalization entail the reduction of tariff (i.e., tax) and non-tariff (e.g., regulation) barriers to the flow of goods, services, and capital throughout the global economy (28). This is primarily accomplished through bilateral (between two countries) and multilateral (between three or more countries) trade and investment agreements, which establish mutual commitments to liberalize one or more sectors of a country's economy for the benefit of partner countries or their nationals. Multilateral trade liberalized rapidly after the end of World War II, and was first governed by the General Agreement on Tariffs and Trade (GATT), which came into force in 1948. Beginning in 1995, the World Trade Organization (WTO) took the place of the GATT as the primary institution governing global trade. More than 80% of all countries now belong to the WTO; in July 2016, Afghanistan became the 164th nation to join (29).

The continued success of the WTO depends on regular renegotiation to update countries' various commitments and review national tariff schedules, which establish import taxes for all products. The latest round of negotiations (the "Doha Round") began in 2001, but never concluded due to difficulties in reaching consensus on a number of issues (30). Meanwhile, as WTO negotiations have stalled, countries have created more regional trade agreements (RTAs) between two or more countries, as an alternative approach to further liberalize trade. Recently, the number of RTAs has dramatically increased: in 2000, less than 100 RTAs had been notified to the WTO, including some that were not in force (31); as of mid-2017, 297 RTAs were in force (32). The U.S., the

European Union, Australia, Chile, China, and Japan are among the countries party to the greatest number of RTAs (32).

Many RTAs are actually trade *and investment* agreements, including provisions that govern both types of activities. While trade liberalization facilitates the exchange of goods and services, investment liberalization permits the flow of capital, allowing foreign companies and individuals to invest in new markets. International investment agreements (IIAs), which now number over 3,300 (33), have proliferated even more rapidly than trade agreements; the vast majority of these are bilateral investment treaties (BITs) (33). Germany, Switzerland, China, France, and the U.K. currently have the greatest number of BITs in force (33).

The key commitment in all trade and investment agreements, which underlies tariff and non-tariff measures alike, is that foreign and domestic products and capital be accorded equal opportunity to participate in the national market. This comprises two trade norms referred to as "non-discrimination": "national treatment" and "most favored nation" (34). A policy that differentially and disadvantageously affects the sale of a foreign good or service or a foreign investment may be accused of being disguised protectionism, and raised as a possible violation of a trade or investment commitment. This is a key potential point of contention for any health policies that seek to discourage or promote consumption of goods or services based on their value for health – if, for example, less healthy items are disproportionately of foreign origin or financed by foreign capital, the policy can appear discriminatory, leading to a trade or investment dispute.

Trade and investment agreements also typically contain norms disciplining member countries' regulations that set health, environmental, and safety standards, even if these are non-discriminatory. The WTO Agreement on Sanitary and Phytosanitary Standards (SPS), for example, provides that health standards should be no more trade restrictive than necessary and the WTO Agreement on Technical Barriers to Trade (TBT) governs packaging, including health-related labels. Investment agreements typically require that laws, including those that regulate health, must be "fair and equitable," a standard open to wide interpretation. Trade and investment rules such as these can give rise to disputes about the validity of health, safety, and environmental regulations, in addition to any concerns arising from whether these measures are discriminatory.

An important trend in more recent agreements is toward deeper integration. RTAs now frequently include concessions beyond those required by WTO membership, which are deemed "WTO-plus" (further levels of commitment) and "WTO-X" (new types of commitments) provisions (35). As existing agreements have already substantially reduced import tariffs for many products, additional provisions in new agreements increasingly focus on non-tariff measures (36). This is a broad category of policies; examples of non-tariff measures include inspection requirements, labeling standards, quotas, price controls, and rules for government procurement (37), i.e., "all measures except tariffs" (36).

Another key feature of modern regional and bilateral trade and investment agreements is the inclusion of investor-state dispute settlement (ISDS). This creates a mechanism to allow not only countries to file disputes against one another (as is the case under the WTO dispute settlement system), but also for private investors to directly sue

foreign governments (38). With ISDS now in place through thousands of agreements, the number of investment disputes has rapidly escalated, from less than ten cases per year before 2000 to 50-60 cases per year in 2011-13 (39). Fighting these cases can be prohibitively expensive for smaller or poorer countries; Michael Bloomberg corralled funding to pay Uruguay's legal fees when it was sued through ISDS by Philip Morris over a tobacco control policy (40).

In trade and investment agreements, all country parties make reciprocal commitments; however, imbalances of economic and political power between nations can create inequitable concessions (35)(41). In multilateral and bilateral negotiations alike, lower income countries have less bargaining power, placing them at a disadvantage (42). Distinctions have been drawn between North-North and South-South RTAs versus North-South RTAs, emphasizing that the similarity or discrepancy in economic power of signatory countries affects the content of agreements (43). In the absence of successful renegotiation within the WTO framework, the continuing proliferation of regional and bilateral treaties raises the concern that unfavorable concessions agreed to by less powerful countries may steadily escalate in volume and scope, exacerbating any negative implications for public health in these countries.

Public health significance

Constraints of political will, financial resources, and available medical technologies currently make widespread treatment of the coinciding global epidemics of cardiovascular diseases, chronic respiratory diseases, cancers, diabetes, and other major NCDs infeasible. As a result, the optimal strategy to reduce NCD-related morbidity and mortality worldwide is strengthening prevention, which will require improved

understanding of the determinants of these epidemics and the effectiveness of policies and interventions intended to decrease exposure to key risk factors.

Globally, policies liberalizing trade and investment are on the rise, suggesting their influence as underlying determinants of the global NCD epidemic will only increase in significance. As these processes continue, additional research is needed to elucidate the nature of their impacts on consumption of nutrient-poor foods and beverages, tobacco, and alcohol, and resulting contribution to NCD morbidity and mortality. Much of the existing literature on these topics is comprised of legal and policy analyses that discuss the implications of trade and investment agreements for public health, but do not measure impacts, and case studies that quantify relationships for a limited number of countries. Additional cross-country quantitative research can help to establish the generalizability of relationships observed in case studies and provide evidence of these impacts on a larger scale.

These questions fall within the broader social determinants of health (SDH) research agenda, which recognizes the significance of macro-level factors with wide-ranging impacts on the environments where people "live, grow, work, and play" (44). In the SDH framework, trade and investment policies are important "causes of the causes" (44) of health outcomes and health inequalities. Additional research on these topics can support their greater recognition as key determinants of the global NCD epidemic and justify their consideration in proposed policy solutions.

Literature review

Health-related impacts of global trade and investment flows

There are a range of direct and indirect connections between the flow of traded goods and services, cross-border investments, and public health. The primary impact attributed to trade liberalization and, to a lesser extent, investment liberalization is fostering economic growth, but arguably also increasing economic inequality, both of which have positive and negative impacts on health (45). Perhaps the earliest observed effect of trade on health was through the spread of infectious diseases facilitated by greater connectivity between people (46). Studies have also explored indirect impacts on health as a result of trade-related activities that exacerbate pollution, deplete natural resources, and cause environmental degradation (27). Other studies have examined indirect health impacts due to changes in working conditions: either reducing the availability of higher-wage positions or decreasing worker protections (27).

Another set of pathways affects the provision of health services: by allowing greater movement of providers and patients, liberalization can exacerbate "brain drain" and facilitate "medical tourism," fostering the misallocation of health workers based on populations' ability to pay for services (47)(48). In addition, affordable access to medicines may decline as a result of commitments in trade and investment agreements that extend the length and scope of intellectual property rights, creating barriers to the production of cheaper generic medications (49). Additional examples of health impacts exist (e.g., increasing or decreasing levels of malnutrition from changes in food security, the effects of economic insecurity and inequality on psychosocial stress and social cohesion) (50)(51)(52)(45), but the focus of this research is how trade and investment

policies and patterns impact the development of NCDs through changes in dietary, tobacco, and alcohol consumption. The following sections review this literature, with an emphasis on quantitative research on these topics.

Quantitative assessments: dietary consumption

A number of studies have examined associations between trade and investment policies and patterns of dietary consumption (53). This body of research builds on several descriptive studies that document trends towards more Western diets in LMICs, without explicitly implicating trade and investment liberalization as drivers of these changes (54). Many of these studies are regional or country-level, assessing one or more countries in the Western Pacific (55)(56), Latin American (57), or southern African regions (58)(59), employing descriptive analysis of longitudinal consumption trends. One or more of these studies have identified positive associations between trade or investment liberalization and greater consumption of animal products, processed foods, and SSBs.

At least three studies have explored these longitudinal associations in larger samples of countries; SSBs have been the major area of focus within this literature. One analysis of 50 low- and middle-income countries identified a positive correlation between the relative value of foreign direct investment (FDI) and increased sales of processed foods (26). An additional cross-sectional analysis in that study found that among 35 LMICs, those with a free trade agreement (FTA) with the U.S. had, on average, 60% higher soft drink sales in 2010 than those without a U.S. FTA. A second longitudinal study examined 25 high-income countries between 1999 and 2008, finding market deregulation was associated with greater fast-food consumption (60). A third study assessed the relationship between SSB applied tariff rates, imports, and sales in 44

LMICs, from 2001-14, finding a significant relationship between lower tariffs and higher imports and between higher imports and higher sales; the link from lower tariffs to higher sales was not significant (61). As an alternative explanatory measure, economic globalization was significantly positively related to SSB imports and sales.

Most recently, three studies have explored these relationships using natural experiment designs, which provide stronger evidence of possible causality than simple associations. Baker, et al. compared SSB imports and sales in Peru, before and after it joined a U.S. FTA, with Bolivia serving as a control (62). The results suggested that FDI into Peru increased after the FTA was ratified and the FDI trend was closely mirrored by the SSB production trend, while SSB imports did not change. The authors concluded these patterns suggested a shift from imports to investments in local production of SSBs after entering into the FTA. In a similar study, Schram, et al. assessed changes in SSB sales after Vietnam joined the WTO, using the Philippines as a control, finding SSB sales increased significantly only in Vietnam after its WTO accession (63). Finally, Barlow, et al. examined consumption of high-fructose corn syrup in Canada after joining the North American Free Trade Agreement (NAFTA), finding this significantly increased compared to a synthetic control constructed from other high-income countries (64).

Quantitative assessments: tobacco consumption

Four cross-country longitudinal analyses have assessed the relationship between trade or investment liberalization and tobacco consumption. The first study utilized data on per capita cigarette consumption in ten Asian countries, between 1970 and 1991, and compared four countries open to U.S. tobacco imports to six countries closed to those imports (65). The findings supported a 10% increase in per capita consumption in 1991

among countries open to U.S. tobacco imports, versus those countries that were closed. The second study examined 42 countries, from 1970 to 1995, and modeled per capita cigarette consumption as a function of trade openness (using imports and exports as a percentage of gross domestic product (GDP) as the indicator) (66). That study found a positive relationship between trade openness and tobacco consumption, although this effect varied by country income level: ranging from the strongest relationship among low-income countries to insignificant among high-income countries. The third study is the same longitudinal study described above, which explored processed food consumption in 50 LMICs (26). That study also identified a positive correlation between the relative value of FDI and increased sales of tobacco. The fourth study modeled tobacco consumption in 39 sub-Saharan African countries, from 1995-2012, as part of a path analysis of cardiovascular disease mortality (59). Those findings suggested levels of trade and investment liberalization were significant predictors of tobacco consumption.

Quantitative assessments: alcohol consumption

Of the three types of unhealthy commodities, alcohol has been the focus of the least amount of research to date (67). The previously described longitudinal study that explored processed food and tobacco consumption in 50 LMICs also identified a positive correlation between the relative value of FDI and greater sales of alcohol (26).

Quantitative assessments: NCD-related health outcomes

A few studies have utilized longitudinal data to examine the association between trade or investment liberalization and NCD-related health outcomes, with or without explicit consideration of the role of unhealthy commodity consumption as a mechanism of this relationship. As outcome measures, these studies have assessed obesity rates

(68)(69), mean BMI (60)(70), and cardiovascular disease mortality (59), across 25 to 79 countries, over a period of ten to 20 years. (One study examining mean BMI used cross-sectional data only). These studies used various indicators for the independent variables: indices of globalization, levels of FDI, the value of imports and exports as a percent of GDP, and mean tariff levels. Across these studies, the findings support an association between greater trade or investment liberalization and worse NCD-related health outcomes.

Key components of trade and investment agreements for unhealthy commodities

The literature described above establishes the presence of relationships between trade and investment (both particular policies and various measures of liberalization and flows) and NCD risk factors, but provides little analysis of *how* these are linked. Quantitative studies using tariff levels have implicitly focused on reduced barriers to the importation and sale of commodities – this is likely the primary mechanism and the most easily quantifiable. Current understanding of other mechanisms comes primarily from qualitative research, which identifies two additional components of trade and investment agreements that can impact the consumption of unhealthy commodities. One mechanism is through limitations imposed on non-tariff barriers such as labeling and marketing regulations, which can restrict governments' abilities to enact health policies – referred to as reduced "policy space" for health (71). The other mechanism is through limits on other non-tariff barriers – government subsidies and import and export restrictions for agricultural products (72) – which can alter the composition and prices of a country's food supply. A less discussed, but possible additional mechanism of these relationships is a reduction in regulatory or enforcement capacity for health policies due to reduced

government funding from lower tariff revenues after liberalization (59). However, this may be offset, in whole or in part, by increases in tax revenue due to rising incomes associated with economic liberalization (43).

Of these mechanisms, the implications of reduced policy space for health have been the focus of the greatest amount of qualitative research, primarily prospective policy and legal analyses of new agreements (73)(74)(75)(76)(77). Reduced policy space include provisions that restrict governments' powers to enact labeling requirements, create advertising restrictions, or raise non-import taxes (78) – all policy tools which could be employed to discourage consumption of unhealthy products (79). Research in this area has drawn on previous examples of health policies being challenged or repealed, combined with legal analysis of the text of new agreements, to assess likely encroachments on health policy space created by new commitments. In commonly cited examples, countries have enacted health-promoting policies, only to have them challenged within the WTO legal system. For example, Mexico's tax on soft drinks sweetened with corn syrup, implemented in 2002, was repealed after the U.S. won a WTO dispute claiming the law protected the domestic sugar industry (80).

In other cases, the threat of litigation alone has sufficiently deterred countries from enacting new policies – deemed the "chilling" effect (81). An example comes from Thailand, where, in 2006, a "traffic light" labeling scheme was proposed for chips, biscuits, crackers, and selected other snacks in order to discourage children's consumption of junk food (82). The U.S. raised concerns in a WTO committee meeting, stating that the proposed labels:

> "…deviate from the prevailing scientific and technical information on

> health and nutrition (e.g., by not focusing on total diet and portion size) and have the potential to tarnish in the minds of Thai consumers the reputation of all products within certain food groups (even variations with lower salt, fat, and sugar) and to distort trade in these products" (82).

Thailand subsequently reneged this proposed legislation in lieu of a milder alternative, which the U.S. still raised for discussion due to "some of the same concerns" (82). In this egregious case, the U.S.'s pressure on Thailand, in the interest of protecting food industry sales, clearly precluded implementation of a policy that could reduce childhood obesity.

Researchers caution that the problem of health policies being deterred by commitments in trade and investment treaties is exacerbated between countries party to bilateral and multilateral agreements outside of the WTO, because of the deeper provisions, as well as the special forms of arbitration included in most investment agreements, namely ISDS (73). While trade treaties typically contain exceptions to commitments for certain objectives, including the protection of human health, interpretation of these exceptions has varied across cases (83). The current consensus is that not all health measures fulfill the necessary conditions to qualify for exemption from these commitments (67).

Non-tariff barriers pertinent to agricultural production are likely most relevant for changes in dietary consumption and may affect tobacco or alcohol consumption only moderately or in a select group of countries. Existing research on this topic, also predominantly policy analyses, has explored the implications of the agricultural policies of the WTO, which took effect in 1995, for the content and price of domestic food supplies (50). In some cases, agricultural subsidies to protect producers in high-income countries have remained permissible while LMIC governments have had to eliminate

similar subsidies, but more research on these impacts is needed (25). Quantitative restrictions forbidding the use of import and export quotas have also disadvantaged LMICs, allowing high-income country agricultural products to depress global commodity prices (72). Overall, WTO agricultural policies appear to have reduced domestic food production and increased reliance on imports in LMICs (72).

Gaps in the literature

This existing literature establishes the presence of associations between various measures of global trade and investment and the consumption of nutrient-poor food and beverages, tobacco, and alcohol, but several gaps in knowledge remain – both in terms of scope and methods. Regarding scope, very few studies have investigated alcohol consumption and more research on this topic is needed. While a relatively larger number of studies have examined impacts on tobacco consumption, these do not include data from the most recent years during which bilateral and multilateral agreements have proliferated, warranting updated analyses. Finally, many quantitative studies examine only one country or region; additional studies are needed that examine specific relationships over a broader range of countries, to assess which effects are generalizable. Methodologically, there is a paucity of analyses using more complex study designs for causal inference. While trade and investment policies can likely never be investigated with randomized trials, greater use of quasi-experimental approaches may be feasible.

An additional challenge is the wide range of indicators used for explanatory variables, which capture slightly different aspects of trade and investment. There is currently no consensus regarding the most appropriate measures of trade and investment liberalization and when and how to apply these to explore different relationships (84). For

example, there may be distinct impacts of: trade liberalization versus investment liberalization; WTO membership versus joining a bilateral or regional agreement; and which countries are party to an agreement, particularly their relative economic power. Distinguishing the possible unique effects of these scenarios requires more refined indicators and models. However, a similar debate regarding appropriate indicators for studying other impacts of trade and investment liberalization exists in the economics literature (84). Improved explanatory indicators could also facilitate exploration of another key gap in the literature: understanding the mechanisms of the relationships between trade and investment liberalization and consumption of unhealthy commodities. For example, studies utilizing a binary indicator for membership in an agreement are likely capturing impacts through several mechanisms, whereas studies using tariff levels or investment flows may be capturing a much more specific set of pathways.

This dissertation contributes to filling these gaps in existing research through three studies that expand the scope and methods of quantitative assessments of the impacts of trade and investment liberalization on dietary, tobacco, and alcohol consumption. The first study investigates the impacts of joining the WTO on: alcohol consumption, relatively neglected in the literature to date, tobacco consumption, for which very recent studies are not available, and several specific dietary categories that have not been widely investigated. The second study assesses the effects of joining a U.S. FTA on sales of processed foods and beverages, including infant foods. Furthermore, these two quantitative studies examine relatively broad sets of countries over time and employ natural experiment designs, strengthening the ability to draw conclusions about the causality of any observed relationships. The third study concludes with a critical

review of methodological approaches for quantitative assessment in this literature, identifying relevant studies through a review of reviews and developing recommendations to guide future research.

Conceptual model

In 2011, Labonte and colleagues published a conceptual model illustrating the ways trade liberalization affects NCDs (85). Two other review articles provide a synthesis of the trade and NCD literature, with a focus specifically on countries in Asia (86)(87). Using Labonte's model and these reviews as a starting point, the conceptual model guiding this research also incorporates models developed by Schram (59), Friel (88), and Thow (25). This adapted model is shown in Figure 1.1.

Detailed published conceptual models describe changes in food systems initiated by liberalization of trade and investment, however, these pathways for tobacco and alcohol have not been as comprehensively elaborated in the literature. For the purposes of this research, it is assumed that food system changes largely parallel changes in systems for the distribution, promotion, and sale of tobacco and alcohol. One review of studies assessing determinants of alcohol consumption in African countries supports this assumption (89). Finally, while this conceptual model includes family-level and individual-level determinants of consumption, the analytical model guiding this research focuses strictly on macro-level determinants of individual consumption.

At the top of the figure, trade and investment policies are grouped into three key types: multilateral agreements, bilateral agreements, and macroeconomic reforms with trade and investment provisions. These policies contain commitments that act through

one or more of the mechanisms in the box below: reductions in tariff and non-tariff barriers to the movement of goods, services, and capital; changes in subsidies, quotas, or other supports for domestic agriculture; and constraints on policy space for health and other health-related sectors. These components of liberalization then affect trade and investment flows, as measured by the volume and value of goods, services, and capital investments entering and leaving each country.

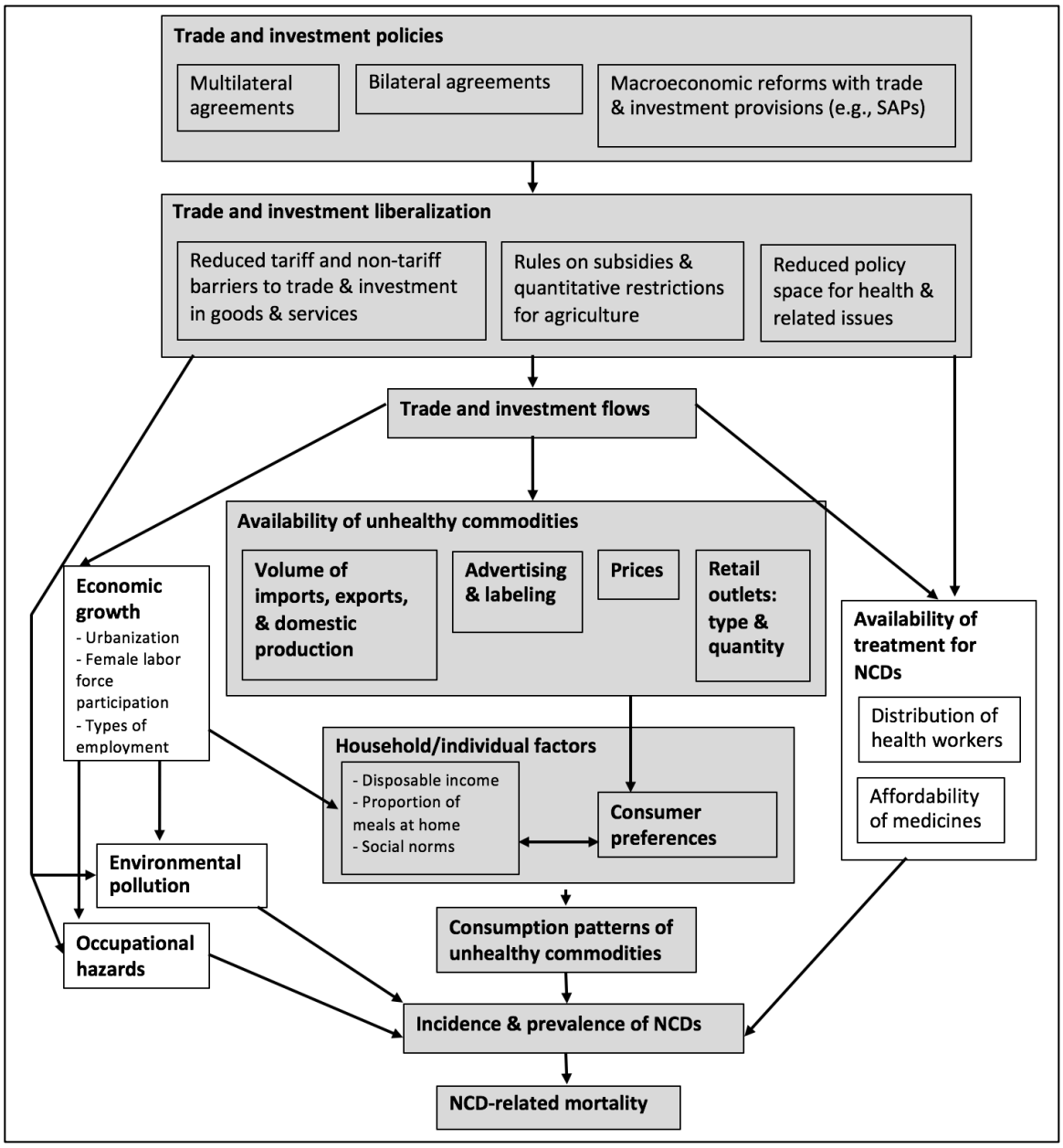
On the left side of the figure, the effect of trade and investment on economic growth is shown, which has been found to positively correlate with increasing urbanization, greater female labor force participation, and shifting patterns of employment, across countries (90). These societal-level changes in turn dictate family- and individual-level factors, particularly: the amount of disposable income; the number of meals eaten away from home (linked to women entering the labor force and changing forms of employment); and social norms regarding the desirability of store-bought food and women's use of tobacco and alcohol (91)(92). Economic activity also impacts environmental pollution and exposure to occupational hazards, which pose significant risks for certain NCDs; both of these are also more directly affected by trade and investment policies (93)(94). On the right side of the figure, impacts on NCD treatment are illustrated, which occur due to changes in the distribution of health workers and affordability of medicines (95); these are shown to primarily impact the prevalence of and mortality due to NCDs (as opposed to incidence).

The middle portion of the figure displays the influence of trade and investment flows on the availability of unhealthy commodities through a variety of means: impacting the volume and type of agricultural production and imports and exports; permitting

additional food advertising and promotion; introducing new forms of retail; and altering the prices of products (91). These changes in turn dictate consumer preferences, which interact with and reinforce other family- and individual-level factors, collectively affecting the consumption of food, tobacco, and alcohol (88). The bottom of the figure illustrates the contribution of poor diet (particularly, low fruit and vegetable consumption and high consumption of animal fats, oils, processed foods, and SSBs), tobacco, and alcohol, to the incidence, prevalence, and consequent mortality due to several NCDs (14)(15)(16).

The shaded portions of the model indicate specific pathways between trade and investment policies and NCDs that are examined in this research. Other aspects of economic growth, environmental pollution, occupational hazards, and the availability of health services are acknowledged to be impacted by trade and investment policies and affect NCD-related morbidity and mortality, but are outside the scope of this research.

Figure 1.1. Conceptual model of the impacts of trade and investment policies on non-communicable diseases.



Shaded area indicates the scope of this research. SAP = structural adjustment program; NCD = non-communicable disease.

Specific aims, research questions, and hypotheses

This research has three specific aims. The aims, research questions, and hypotheses (where relevant) for each are listed below.

Aim 1: Investigate the impacts of joining the World Trade Organization (WTO) on national-level tobacco, alcohol, and dietary consumption

Research Question 1.1: How do trends in tobacco consumption change after countries join the WTO?

Hypothesis 1.1: Tobacco consumption increases after countries join the WTO, relative to countries not joining the WTO.

Research Question 1.2: How do trends in alcohol consumption change after countries join the WTO?

Hypothesis 1.2: Alcohol consumption increases after countries join the WTO, relative to countries not joining the WTO.

Research Question 1.3: How do trends in consumption of foods with established protective or harmful effects for the development of non-communicable diseases change after countries join the WTO?

Hypothesis 1.3: After countries join the WTO, consumption of red meats and animal fats, edible oils, and sugars increase; consumption of starches and nuts, seeds, and legumes decline; and changes in consumption of fruits and vegetables and seafood are highly variable, relative to countries not joining the WTO.

Aim 2: Investigate the impacts of joining a free trade agreement (FTA) with the United States on national retail sales of processed foods and beverages

Research Question 2.1: How do trends in sales of ultra-processed products change after countries join a U.S. FTA?

Hypothesis 2.1: Sales of ultra-processed products increase after countries join a U.S. FTA, relative to countries not joining a U.S. FTA.

Research Question 2.2: How do trends in sales of processed culinary ingredients change after countries join a U.S. FTA?

Hypothesis 2.2: Sales of processed culinary ingredients increase after countries join a U.S. FTA, relative to countries not joining a U.S. FTA.

Research Question 2.3: How do trends in sales of minimally processed foods change after countries join a U.S. FTA?

Hypothesis 2.3: Sales of minimally processed foods decrease after countries join a U.S. FTA, relative to countries not joining a U.S. FTA.

Research Question 2.4: How do trends in sales of baby food change after countries join a U.S. FTA?

Hypothesis 2.4: Sales of baby food increase after countries join a U.S. FTA, relative to countries not joining a U.S. FTA.

Research Question 2.5: How does the ratio of sales of fresh versus processed fruits and vegetables change after countries join a U.S. FTA?

Hypothesis 2.5: The ratio of sales of fresh versus processed fruits and vegetables declines after countries join a U.S. FTA, relative to countries not joining a U.S. FTA.

Research Question 2.6: How does the ratio of sales of fresh versus processed meat and seafood change after countries join a U.S. FTA?

Hypothesis 2.6: The ratio of sales of fresh versus processed meat and seafood declines after countries join a U.S. FTA, relative to countries not joining a U.S. FTA.

Aim 3: Critically review the quantitative literature on trade and investment policy and diet, tobacco, alcohol, and related health outcomes to develop recommendations to guide future policy relevant research

In studies examining the impacts of trade and investment policy on diet, tobacco, alcohol, and related health outcomes, to date:

Research Question 3.1: What data sources have been used?

Research Question 3.2: What indicators of trade and investment policy have been used?

Research Question 3.3: What health outcome and risk factor indicators have been used?

Research Question 3.4: What study designs have been used?

Research Question 3.5: What confounding, mediating, and moderating variables have been examined?

Research Question 3.6: What are the strengths of the data and methods used?

Research Question 3.7: What are the limitations of the data and methods used?

Research Question 3.8: What lessons can be drawn from the existing literature, to inform future policy relevant research?

Chapter 2: Methods

Study design

Aims 1 and 2

The two quantitative studies (Aims 1 and 2) both use a natural experiment study design, which is a technique for exploring causation from observational data in cases when random assignment of an intervention is not feasible (96). In this type of study, values of an outcome of interest are compared before and after an intervention to assess whether the intervention is associated with any change in the outcome; the key assumption is that trends in the outcome would be similar in the absence of the intervention. In these two studies, the interventions of interest are distinct policy changes (accession to the WTO and to a U.S. FTA, respectively). Both analyses have characteristics that improve upon the basic natural experiment design: the use of multiple exposed and unexposed units, as well as the availability of several pre- and post-intervention observations (96).

Aim 3

The third study is a particular type of literature review – a critical review – distinguished by its aim to "evaluate what is of value from the previous body of work,…[which] may provide a 'launch pad' for a new phase of conceptual development and subsequent 'testing'" (97). This type of review was selected for this topic for two key reasons. First, two closely related reviews (98)(99) were published in the year preceding this study and the goal was to make a novel contribution to the literature, avoiding duplication with those studies. Second, substantial inconsistency in terminology and

methods is evident in this literature, necessitating an examination of the merits of different approaches and an attempt to build consensus. A critical review may or may not include a comprehensive search of the literature – in this case, this was attempted – but the distinguishing aspect is the evaluative component, which seeks to inform future work.

Quantitative data (Aims 1 and 2)

Overview

The two quantitative studies (Aims 1 and 2) utilize country-level panel datasets with multiple variables, constructed by compiling data from a range of national and international sources. Outcome data for the first study come from the Food and Agriculture Organization (FAO) Food Balance Sheets and Commodity Balances, which are publicly available for download. Outcome data for the second study come from the Euromonitor International Passport database, which is available for purchase; these data were accessed through the Johns Hopkins University institutional subscription.

Covariate data for the two studies come from many of the same sources. These were primarily accessed from publicly-available databases maintained by international organizations (Table 2.1). Additional data on membership in and dates of entry into force of several international agreements came from international organizations and relevant national agencies (also publicly available):

1. World Trade Organization (WTO)
2. United Nations Treaty Collection
3. Office of the United States Trade Representative (USTR)
4. United States Office of Trade Agreements Negotiation and Compliance

5. United Nations Conference on Trade and Development (UNCTAD)
6. European Commission (EC)
7. Switzerland State Secretariat for Economic Affairs (SECO)

The dataset used for each study was constructed as panel data, with one observation for each country-year. While the number of countries and years of available data varied by source, the master dataset included 396 variables for 243 unique countries, from 1950 to 2016; the total number of observations was 16,271. Not all variables or observations were needed for the analyses in Aims 1 and 2; all variables utilized, and the data source for each, are presented in Appendix A.

Table 2.1. Sources of longitudinal covariate data used in Aims 1 and 2

Data Source	Available Data	
	Countries	**Years**
World Bank World Development Indicators (WDI)	217	1960-2016
United Nations Population Division (UNPOP) World Population Prospects (WPP)	232	1950-2100
United Nations Population Division (UNPOP) World Urbanization Prospects (WPP)	232	1950-2050
Institute for Health Metrics and Evaluation (IHME) Global Health Data Exchange (GHDx)	210	1950-2015
International Monetary Fund (IMF) World Economic Outlook (WEO)	192	1980-2016
The Pew Research Center	232	1990, 2010
Center for Systemic Peace Polity Project	167	1800-2015

Data sources

Each of the above data sources is described in detail below.

Aim 1 outcome data: FAO Food Balance Sheets and Commodity Balances

The Food and Agriculture Organization of the United Nations (FAO) maintains estimates of each country's annual supply of food and other commodities, based primarily on data from national statistical offices. Several quantities are available,

including values of production, trade, and inputs, among others. The data selected for this analysis (supply available for human consumption) were chosen to most closely approximate the quantities of interest in these research questions, i.e., actual values of human consumption. Data for all food categories and alcohol were taken from the "Food Balance Sheets" (100); tobacco data were taken from the "Commodity Balances – Crops Primary Equivalent" (101).

At the time data were downloaded (April 14, 2017), these datasets covered 176 countries (as well as several former countries and regional aggregates), from 1961 to 2013. The "food balance sheets" are constructed by summing production and import values, subtracting exports, and adjusting for any change in stocks and approximate wastage, to generate estimates of quantities available for human consumption. The "commodity balance – crops primary equivalent" data provide similar balance estimates for selected food and agricultural commodities, including tobacco, which is not included in the food balance data.

For all food categories, total and per capita supply quantities are provided, as well as supplies in terms of caloric value and protein and fat content (calculated by applying food composition factors). For each food item, data in kilograms per capita were used instead of kilocalories per capita because the former requires less transformation and therefore, less opportunity to introduce estimation error into the data values. Previously published studies using this data source have also elected to present these data in units of weight as opposed to nutrients (102)(57). For alcohol, data in total weight (units of thousands of metric tonnes) were selected instead of per capita data, in order to apply a more relevant population denominator (population aged 15 and older, instead of total

population). For tobacco, the quantity of interest was the domestic supply quantity, in units of metric tonnes; the same population denominators used for alcohol (ages 15+) were applied to tobacco data.

Food balance data are available at two levels – item groups and item aggregations – with item groups being more specific, summed to generate the broader aggregations. To construct the outcomes used in this analysis, data at the more specific item group level were chosen to generate seven food outcome categories of interest: fruits and vegetables; nuts, seeds, and legumes; edible oils; starches; sugars; red meats and animal fats; and seafood. Additional detail on the selection of food outcomes of interest is provided in the methods section of Chapter 3; and the individual item groups summed to generate each outcome are presented in Appendix C. For the alcohol outcome, data for the item aggregation "alcoholic beverages" were used, which compiles the following item groups: "beer," "wine," "beverages, alcoholic," "beverages, fermented." The tobacco outcome was constructed from the item group "tobacco," which compiles the items: "tobacco, unmanufactured," "cigarettes," "cigars, cheroots," and "tobacco products, not elsewhere specified."

This data source was selected for the first study because of the large number of products covered and the comprehensiveness of the data in terms of countries and years. Using these data permitted assessment of a broad set of outcomes, selection of a sample from nearly all possible countries, and analysis over a long time horizon – all necessary features for the study design in the first aim.

Aim 2 outcome data: Euromonitor International Passport Database

Euromonitor International produces the Passport Global Market Information Database (GMID) (103), which provides historical and forecasted demographic, economic, and marketing statistics for a wide range of industries, covering up to 205 countries. Data are compiled from company reports, industry publications, government statistics, and interviews (103), to generate product-specific estimates of sales volumes, average prices, brand shares, and distribution, among other information. Data used for this analysis come from available datasets for the "packaged food," "fresh food," and "soft drink" industries. All available product categories were selected from each of these three industries (for a total of 39 product categories).

At the time data were downloaded (March 14, 2017), datasets for these industries covered 80 countries (all high-income and selected middle-income countries, with no data available for the lowest income countries), from 2002 to 2016. Data are updated at least annually to provide historical estimates for the preceding 15 years; available forecasted estimates through 2021 were not utilized.

For all products, the quantity of interest was the total volume of retail sales, which combines "on-trade" sales (through food service outlets) and "off-trade" sales (through retail establishments). All data were downloaded in units of thousands of metric tonnes (foods) or millions of liters (beverages) and converted to per capita values using population estimates from the United Nations *World Population Prospects* (described below). Total population was used as the denominator for all products, except baby food, for which the population under age five was used as the denominator.

To construct the outcomes used in this analysis, product categories were summed to generate six outcome variables: baby food, minimally processed foods, processed

culinary ingredients, ultra-processed products, the ratio of sales of fresh versus processed meat and seafood, and the ratio of sales of fresh versus processed fruits and vegetables. Additional detail on the selection of outcomes of interest and the individual product categories comprising each are provided in the methods section of Chapter 4 and in Appendix E.

These data were chosen as the outcome data for the second aim because they permit examination of several products that are highly relevant to U.S.-based food and beverage companies, which are the focus of the research questions in this study.

Covariates

World Bank WDI

The World Development Indicators (WDI) (104), published by the World Bank, compile social, demographic, and economic data from a range of international sources, covering 217 countries, annually, from 1960 to 2016. Female labor force participation rates among women age 15 and older were taken from this data source, using estimates produced by the International Labor Organization (ILO), supplemented with national estimates, also available in the WDI. The ILO estimates are based on national and imputed data sources, harmonized for comparability across countries and over time. These estimates count labor force participants as persons who "produce goods or services for pay or profit"; this definition encompasses part-time work and employment in the informal sector (105). ILO estimates were available for 186 countries, from 1990 to 2014.

UNPOP World Population Prospects

The World Population Prospects (WPP) (106) are produced by the United Nations Department of Economic and Social Affairs, Population Division (UNPOP), and provide

key demographic indicators for 232 countries, from 1950, with projections to 2100. Annual values for the total, under age 5, and age 15 and older populations, by country, were extracted from the WPP, 2015 edition.

UNPOP World Urbanization Prospects

UNPOP also produces the World Urbanization Prospects (WUP) (107), which provides annual estimates of the percent of each country's population living in an urban area, as defined by national statistical offices. For the first study, WUP urbanization estimates as reported in the WDI dataset were used, which covered 215 countries, from 1960 to 2015. For the second study, data through 2016 were needed, so urbanization rates were taken directly from the WUP, 2014 edition, which included estimates for 232 countries, from 1950 to 2050.

IHME Global Health Data Exchange

The Institute for Health Metrics and Evaluation (IHME) produced a dataset of gross domestic product per capita (GDPpc) in 2012, by merging estimates from widely utilized sources of GDP data (the World Bank, International Monetary Fund, Penn World Tables, and Maddison) to generate the most comprehensive series, covering 210 countries, from 1950-2015, which attempts to rectify discrepancies across these various sources (108). This dataset was downloaded from the Global Health Data Exchange (GHDx), a repository of global health data sources hosted by IHME (109). The chosen series was the constant international dollar series (in 2005 dollars), which controls for inflation over time and differences in purchasing power parity across countries. These GDPpc estimates were generated using UNPOP WPP population estimates for the

denominators, making these data consistent with other per capita variables used in this research.

International Monetary Fund (IMF) World Economic Outlook

The International Monetary Fund (IMF) World Economic Outlook (WEO) (110) is one of the aforementioned sources of GDP data. The WEO, 2017 edition, covers 192 countries, from 1980 to 2016. GDPpc estimates from this dataset were used to supplement the IHME dataset, which ends in 2015, in order to generate 2016 GDPpc estimates, as needed in Aim 2.

Pew Research Center

Estimates of the proportion of each country's population that identifies as Muslim were downloaded from The Pew Research Center (111). These data were available for 232 countries, in 1990 and 2010.

Center for Systemic Peace Polity Project

The Polity Project, from the Center for Systemic Peace, provides a range of political variables to describe features of governments and political institutions across countries and over time. A numerical variable characterizing governments on a scale from fully autocratic to fully democratic was taken from the Polity IV dataset (112), which covers 167 countries, from 1800 to 2015.

World Trade Organization

A list of current member countries, observer countries, and joining dates for all members, was taken from the website of the World Trade Organization (29). The membership status of all countries was used as provided on the date these were downloaded (September 18, 2016).

United Nations Treaty Collection

The dates when each participating country joined the Framework Convention on Tobacco Control (FCTC) were downloaded from the United Nations Treaty Collection (113). For each country, there was a date of signature, and most often also a date of one of the following: ratification, acceptance, approval, formal confirmation, accession, or succession. For the purposes of this research, the FCTC was considered to take effect in each country from the date of any action aside from signature (e.g., ratification, acceptance), as each of these actions initiate entry into force of the treaty in the respective country (113).

USTR

Dates of entry into force of all U.S. free trade agreements (FTAs) were extracted from the website of the Office of the United States Trade Representative (USTR) (114).

Office of Trade Agreements Negotiation and Compliance

Dates of entry into force of all U.S. bilateral investment treaties (BITs) were downloaded from the webpage of the United States Office of Trade Agreements Negotiation and Compliance (115).

UNCTAD

The United Nations Conference on Trade and Development (UNCTAD) maintains a database of all international investment agreements in force. From this site, dates of entry into force and partner countries were extracted for all international investment agreements that include the EU (116) and Switzerland (117).

European Commission

Dates of entry into force of all European Union free trade agreements (FTAs) were downloaded from the European Commission (EC) website (118). The EC distinguishes between three types of trade agreements – "customs unions"; "association, stabilization, (deep and comprehensive) free trade, and economic partnership agreements"; and "partnership and cooperation agreements." For the purposes of this research, each of these types of agreements was treated as equivalent.

Switzerland SECO

Dates of entry into force of all Switzerland free trade agreements (FTAs) were extracted from the website of the Switzerland State Secretariat for Economic Affairs (SECO) (119).

Missing data

For all outcome variables and covariates, missing data were either imputed or ignored, using an approach specific to each variable – described in the sections below. In general, sporadic missingness was ignored and/or examined through sensitivity analyses, while imputation was used when values were missing for all countries in selected years. No data needed for these analyses were missing for: population, urbanization, or membership in any of the relevant trade and investment agreements.

FAO food, alcohol, and tobacco balances

The seven dietary outcome variables constructed from the FAO data were generated by summing categories at the item group level into broader outcomes (ranging from six to 17 item groups per outcome). Missing data at the item group level were ignored; the percent of country-years missing data by item group is reported in Appendix C. Thus, for these seven outcomes, a missing value for an outcome variable implies data

were missing for all component item groups. The tobacco and alcohol outcome variables were generated directly from categories available in the FAO data and do not reflect any supplemental aggregation. For these nine outcome variables, data were only missing for Ethiopia, from 1980 to 1992, and Oman, from 1980-89. This missingness was ignored, but the effect of excluding these two countries was explored in sensitivity analyses.

Euromonitor retail sales

Data were missing for the following products, all of which are components of the ultra-processed products outcome: ready meals (Tunisia, 2002-06), concentrates (Peru, all years; Bolivia, all years; Colombia, 2002-05, 2014-16; Korea, 2002-05), ready-to-drink coffee (various years for 15 countries), ready-to-drink tea (various years for eight countries), sports and energy drinks (Tunisia, 2002-04). Missingness for ready meals, concentrates, and sports and energy drinks was ignored because these individual products contributed less than 0.3% to the outcome in these countries in years without missing data; and less than 0.8% across all countries in cases where no data were available for a country for a specific product (concentrates in Peru and Bolivia). In primary analyses, missingness for ready-to-drink coffee and ready-to-drink tea was also ignored, but sensitivity analyses explored the impact of excluding these product categories from the outcome, which contributed 4.5% to 10.6% and 5.3% to 9.0% to the total across all countries in each year, respectively.

Data for selected product groups were labeled as “modelled” for seven countries (exposed group: Costa Rica, Dominican Republic, Guatemala; unexposed group: Bolivia, Ecuador, Tunisia, Uruguay). This applies to all products in the minimally processed foods outcome and the fresh food components of the two fresh/processed ratio outcomes;

as well as sugar and sweeteners, a component of the processed culinary ingredients outcome; and ready-to-drink coffee, in the ultra-processed products outcome category. Modelled data were treated the same as all other data, but in sensitivity analyses the impacts of excluding countries with any modelled data were explored.

GDP per capita

The primary source (IHME) of GDP per capita data (in constant international dollars) was available through 2015 for all countries, but estimates in 2016 were also needed for Aim 2. To fill the missing year, a model-based estimate was generated using supplemental data from the IMF, which only produces a current international dollar series (not adjusted for inflation). First, the relationship between the IHME constant dollar estimates and the IMF current dollar estimates in 2014 and 2015 was modeled with simple linear regression, by country. In the second step, this model was used to predict each country's GDP per capita in constant international dollars in 2016 based on its 2016 current international dollar estimate.

Female labor force participation rate

Estimates of female labor force participation (FLFP) rates from the ILO were only available from 1990 to 2014, with some missingness in intervening years. Most countries also had a national estimate of the FLFP rate available for one or more years. To generate a complete series from 1980 to 2016 for each country, missing data were filled in two steps. First, the ILO estimate was modelled as a linear function of year and the national estimate (when available), by country, and used to predict the ILO estimate in years missing ILO data. Second, linear interpolation was used to fill missing years between 1990 and 2014, and linear extrapolation was used to expand the time series back to 1980

and forward to 2016. The assumption of linearity was based on the observation of generally linear trends in countries with complete data.

Graphs of the resulting estimates over time for each country were visually inspected; the above method was deemed to generate implausible trends for 18 countries. For this subset of countries, linear interpolation and extrapolation were based solely on the ILO estimates and did not include information from national estimates. Finally, for Kiribati, no ILO data were available; estimates from 1980 to 2016 were imputed using the same methods, but based only on national estimates.

Muslim percent of population

Estimates of the percent each country's population identifying as Muslim were needed annually from 1980 to 2013, but were only available in 1990 and 2010. All missing years were filled using linear interpolation and projection, based on the trend between 1990 and 2010. The assumption of linearity was based on research on trends in national religious composition (120).

Literature reviewed (Aim 3)

The data sources for the critical review were quantitative studies in the existing literature, which were identified through a three-step process – a review of reviews, expert review, and reference tracing. First, a literature search was conducted in nine databases for relevant reviews in the peer-reviewed and grey literature, and these were screened for relevance. These databases were selected to cover health, economics, and social science, due to the interdisciplinary nature of the topic. From the eligible reviews, lists of studies (if provided) or references were screened to identify quantitative studies

matching the inclusion criteria of the critical review. Second, the resulting list of quantitative studies was reviewed by the authors as well as two external experts to identify any relevant studies known to the experts that were not yet included on this list. Third, any relevant articles referenced in the quantitative studies were examined to assess whether these met the inclusion criteria and if so, were also added.

Analytical approach

Quantitative analyses (Aims 1 and 2)

Both quantitative studies (Aims 1 and 2) utilize country-level panel data to examine the impact of a discrete policy change occurring in a group of countries, compared to an unexposed group without the policy. Effects are estimated using comparative interrupted time-series models with multiple baselines (i.e., exposed units implement the policy change at different time points). A matching or weighting technique is employed to improve the comparability of exposed and unexposed groups, thereby strengthening the ability to make conclusions about the causality of any observed relationships (121). Additional rationale for the methodological approach used in each study and details on implementation are provided in the methods sections of Chapters 3 (Aim 1) and 4 (Aim 2).

Choice of weighting or matching technique

In the first study, the pool of eligible unexposed countries was only slightly larger (n=26) than the number of exposed countries (n=21). Propensity score weighting was used as the balancing technique in order to maximize the use of available information from unexposed countries. This method assigns a weight to each unexposed unit,

reflecting its similarity to the exposed group, rather than discarding any unexposed units (122). Multiple variables were explored in models to assign weights, as described in detail in Chapter 3.

In the second study, the ratio of unexposed to exposed countries was much higher: n=65 and n=10, respectively. Coarsened exact matching was used to identify the countries in the unexposed group that are most meaningfully similar to exposed countries and to discard the remaining unexposed countries that are not likely to provide useful comparison data (123). The choice of match variables was informed by characteristics used to identify controls in previous natural experiments on these topics (62)(63).

Estimand of interest

In both analyses, the estimand of interest is the average treatment effect on treated (or exposed) units (ATT), as opposed to the average treatment effect (ATE). In these analyses, the unexposed countries are weighted or selected to resemble the exposed group, making the conclusions applicable for countries similar to those in the exposed group. The data do not support estimation of the ATE because the set of countries joining the agreements during the time periods examined in each study is not sufficiently representative of the universe of countries to draw conclusions about this larger group.

Development of regression models

Multivariate linear regression was used to model all outcomes in both studies and multiple model variations were explored. Log-transformed outcomes were tested for selected outcome variables with highly skewed distributions. To account for large variations in baseline values, log-normal models were also examined, but often had trouble converging. Further model variations included altering covariates, testing

different time terms (linear, quadratic, cubic), and utilizing country fixed- and random-effects.

Due to the longitudinal nature of the data utilized in each of these studies, all outcomes were examined for the presence of autocorrelation. Based on graphs of the autocorrelation function of each outcome, it was determined that model residuals for all Aim 1 outcomes are best approximated by a first-order autoregressive structure and all Aim 2 outcomes best fit an exchangeable structure.

In both studies, model selection was informed by fit statistics (e.g., AIC, BIC, Wald test), but final model choices were primarily based on visual inspection of how well predicted values fit the data. The use of weights, random effects, and imposed residual structures (for autocorrelation) can each complicate the comparison of different fit statistics across models with and without these different features (124)(125). Therefore, visualizing fit was preferable for model selection.

STATA commands

All regression models were run in STATA, version 14.2, using the commands: *xtreg* (fixed-effects models with residual correlation structures)*, mixed* (random-effects models)*, regress* (fixed-effects-only models)*,* and *gllamm* (log-normal models). For Aim 1, propensity score weights were included as *pweights*. For Aim 2, matching weights were constructed as *iweights*, but converted to *fweights* for compatibility with the requirements of regression commands.

Methodological quality assessment (Aim 3)

The quantitative studies compiled for the critical review (Aim 3) were analyzed using a novel quality assessment tool, which was designed for this study (provided in

Appendix G). Rather than utilize an existing quality framework, a new tool was developed from the existing literature to tailor the assessment specifically to known and suspected weaknesses of this body of literature. This included objective features of study design, such as sample size, exposure and outcome variables, and types of statistical models or tests, as well as more subjective aspects of quality. These components included whether trade and investment exposures were clearly defined and articulated in research questions; the specificity and appropriateness of chosen indicators; and the robustness of the analysis.

To evaluate and extract information from each study, the quality assessment tool was converted to an Excel file; each study was reviewed and information pertaining to each item in the quality assessment tool was recorded in the Excel file. The results of interest are trends in this literature as whole, as opposed to the quality of individual studies, so most results are presented in the form of the number or proportion of studies with different characteristics.

Human subjects

Aims 1 and 2 utilize country-level aggregate data, from which no individuals can be identified. The critical review (Aim 3) does not involve any data on human subjects. The Johns Hopkins Bloomberg School of Public Health Institutional Review Board reviewed this proposed research on January 19, 2016 and determined this did "not qualify as human subjects research as defined by DHHS regulations 45 CFR 46.102 and does not require IRB oversight." This letter is provided in Appendix B.

Chapter 3: The impacts of joining the World Trade Organization (WTO) on non-communicable disease risk factors: a natural experiment comparing new WTO member states with non-members, 1980-2013 (Aim 1)

Abstract

Membership in the World Trade Organization (WTO) requires countries to reduce barriers to imports, which may increase the availability of products with both harmful and protective effects for the development of non-communicable diseases (NCDs). This study uses a natural experiment design to compare trends in consumption of tobacco, alcohol, and seven key food groups, between 1980 and 2013, in 21 countries joining the WTO after 1995 and 26 non-member countries. Outcome-specific propensity score weights are used to improve the comparability of these two groups of countries. Annual country-level data for all outcomes come from the Food and Agriculture Organization food and commodity balances. Analyses are conducted in a comparative interrupted time-series framework using multivariate random-effects linear models, adjusted for known key confounders: gross domestic product (GDP) per capita, the percent of the population living in an urban area, and the female labor force participation rate. Additional control variables are included in models for tobacco (ratification of the Framework Convention on Tobacco Control (FCTC)) and alcohol (percent of the population identifying as Muslim). Results suggest that following accession to the WTO, countries experience large immediate increases in fruit and vegetable consumption and steady gradual

increases in tobacco and alcohol consumption, compared to weighted non-member countries. No statistically significant impacts on consumption of red meats and animal fats; seafood; nuts, seeds, and legumes; starches; or edible oils are detected; and results for sugar consumption are inconsistent across model variations. Overall, treatment effects are not consistently significant and estimated random effects indicate substantial remaining country-level heterogeneity in impacts. Results are highly suggestive that membership in the WTO can lead to increases in selected NCD risk factors (tobacco and alcohol consumption) as well as increases in certain protective behaviors (fruit and vegetable consumption), but further exploration of country-specific variation is warranted.

Introduction

Non-communicable diseases (NCDs) now account for the majority of global morbidity and mortality, and are steadily increasing in prevalence worldwide (126). A significant proportion of the growing NCD burden is attributed to consumption of nutrient-poor food, tobacco, and alcohol, three leading risk factors that collectively explain approximately one-quarter of morbidity and mortality worldwide (127). Research examining determinants of increases in these risk factors suggests that globalization and, in particular, trade and investment liberalization – the progressive removal of barriers to the entry of foreign goods, services, and capital – may play a key role (128)(85). Liberalization through trade and investment agreements can increase the availability and reduce the price of these high-risk products (25), and various commitments in these agreements may restrict the policy options governments may employ to discourage consumption (129). Previous studies exploring relationships between trade and investment policies and tobacco, alcohol, and dietary consumption have generally identified a trend towards higher risk consumption patterns as countries liberalize (26)(60)(65). Case studies examining trade-related dietary changes have documented increases in consumption of: high-fat meats in Micronesia (55), highly-processed foods in Fiji (56), and meat and snacks in Central America (57), among other examples.

Few studies of these relationships have utilized cross-country longitudinal data or methods designed for causal inference, limiting conclusions about generalizability and causality from existing studies. A recent systematic review of quantitative research on these topics found that across 11 studies, liberalizing trade and investment was associated with increased imports and consumption of: edible oils, meats, processed foods, and

sugar-sweetened beverages (SSBs), and that results for tobacco were mixed (99). In a sample of 42 countries, between 1970 and 1995, Taylor, et al. found greater trade liberalization (measured by exports and imports as a percentage of gross domestic product (GDP)) was significantly associated with increased cigarette consumption in low- and middle-income countries, but not in high-income countries (66). In a sample of 50 low- and middle-income countries between 1997 and 2010, Stuckler, et al. failed to replicate a similar finding for the relationship between foreign direct investment (FDI) and tobacco consumption, but found a significant positive association between increased FDI and consumption of alcohol and highly processed foods (26). Recent natural experiments of single case-control pairs have identified an increase in SSB sales in Vietnam following its accession to the World Trade Organization (WTO) (63) and no significant changes in SSB sales in Peru following its ratification of a free trade agreement with the United States (62).

One highly influential set of trade policies are the WTO agreements and institutions, which form the predominant global trade regime, although regional and bilateral agreements, covering both trade and investment, have also proliferated in recent years (88). As of 2017, 164 countries were members of the WTO, 126 of whom were original members of the General Agreement on Tariffs and Trade (GATT), the predecessor to the WTO (29). This study contributes new quantitative evidence to the literature on the role of trade and investment liberalization in the global NCD epidemic by utilizing entry into the WTO as a natural experiment to assess resulting changes in NCD risk factors at the national level. Accession to the WTO is a discrete liberalizing event that is comparable across countries, facilitating the comparison of countries joining

the WTO (exposed group) with non-member countries (unexposed group). The objective of this study is to evaluate changes over time in tobacco, alcohol, and dietary consumption in countries joining the WTO, compared to trends in non-member countries, utilizing propensity score weights to improve comparability between the exposed and unexposed groups.

Methods

Study Design

This analysis uses a natural experiment approach to compare consumption patterns in 47 countries, from 1980 to 2013: 21 countries joining the WTO between 1996 and 2008 (exposed group) and 26 countries not in the WTO as of 2011 (unexposed group) (Table 3.1). Natural experiments utilize observational data to mimic the conditions of a randomized experiment, by taking advantage of a change in policy or other exogenous factor, to assess any observable differences in units with versus without the change (96). The specific outcomes examined in this study are: tobacco (total supply); alcohol (all, including beer, wine, and spirits); and seven food groups with particular relevance to the development of NCDs (both protective and harmful): fruits and vegetables; nuts, seeds, and legumes; seafood; red meats and animal fats; sugars; starches; and edible oils. Food categories of interest were selected based on a review of common elements of indices of dietary quality (130)(131)(132)(133) and dietary diversity (134)(135) and the best available evidence on the protective and harmful effects of major food groups for the development of NCDs (136)(137)(138), as well as limitations of the available data. Appendix C lists the specific food item groups summed to generate each

of the dietary outcomes. We hypothesized that following WTO accession, consumption of tobacco, alcohol, edible oils, red meats and animal fats, and sugars would increase; consumption of starches and nuts, seeds, and legumes would decline; and the expected impacts on fruits and vegetables and seafood were unknown.

Original member states of the WTO and all members of the former GATT were excluded because these countries already had the exposure of interest (WTO membership). Nine countries in the unexposed group joined the WTO in the final two years or after the analysis period (Russian Federation, Samoa, and Vanuatu in 2012; Lao People's Democratic Republic and Tajikistan in 2013; Yemen in 2014; Kazakhstan in 2015; and Afghanistan and Liberia in 2016). Data were censored for those countries joining the WTO in 2012 and 2013 to exclude values in or after the year in which they joined. This censoring is not expected to be problematic; existing literature suggests there should not be strong lead effects of entry into the WTO on the outcomes of interest (effects are more likely lagged) (63). Instead, future WTO members make ideal unexposed units because they have a demonstrated likelihood of receiving the exposure of interest. For countries that comprised the former USSR (eight exposed, seven unexposed), the analysis period begins in 1992, when the 15 independent countries were established. Data for Sudan (unexposed group) were censored to exclude data after 2011, when the country divided into two separate nations. The post-exposure period was defined as beginning on each country's individual WTO joining date. The accession process can take many years, but the date of membership reflects the time when treaty provisions become enforceable and is therefore most meaningful as the exposure date for this analysis (139).

Table 3.1. Countries included in analysis, by exposure group and date of WTO membership (exposed group only)

Exposed group (WTO membership date),[1] n=21
Ecuador (21 January 1996)
Bulgaria (1 December 1996)
Mongolia (29 January 1997)
Panama (6 September 1997)
*Kyrgyzstan (20 December 1998)
*Latvia (10 February 1999)
*Estonia (13 November 1999)
Jordan (11 April 2000)
*Georgia (14 June 2000)
Albania (8 September 2000)
Oman (9 November 2000)
*Lithuania (31 May 2001)
*Republic of Moldova (26 July 2001)
People's Republic of China (11 December 2001)
*Armenia (5 February 2003)
Nepal (23 April 2004)
Cambodia (13 October 2004)
Saudi Arabia (11 December 2005)
Viet Nam (11 January 2007)
*Ukraine (16 May 2008)
Cape Verde (23 July 2008)

Unexposed group (WTO non-member as of 2011), n=26
Afghanistan
Algeria
*Azerbaijan
Bahamas
*Belarus
Ethiopia
French Polynesia
Islamic Republic of Iran
Iraq
*Kazakhstan
Kiribati
^^Lao People's Democratic Republic
Lebanon
Liberia
New Caledonia
People's Democratic Republic of Korea
*^Russian Federation
^Samoa
Sao Tome and Principe
**Sudan
*^^Tajikistan
Timor-Leste
*Turkmenistan
*Uzbekistan
^Vanuatu
Yemen

[1]WTO membership dates: https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm
**Former USSR member state (data begin in 1992); **Country divided in 2011 (data end in 2011)*
^Joined WTO in 2012 (Data end in 2011); ^^Joined WTO in 2013 (Data end in 2012)

Data sources

The data sources for all outcomes were the Food and Agriculture Organization (FAO) national commodity balance sheets (tobacco) and food balance sheets (all other outcomes), which measure the annual supply of each commodity, by country, and are widely used as a proxy for consumption (102)(140). Covariate data were compiled from the World Bank World Development Indicators (104) (urbanization and female labor force participation (FLFP) rates), the United Nations Population Division (UNPOP) (106)

(total population and population aged 15 and older), the Institute for Health Metrics and Evaluation (141) (gross domestic product (GDP) per capita), the Pew Research Center (111) (percent Muslim), and the United Nations Treaty Collection (113) (Framework Convention on Tobacco Control (FCTC) ratification dates).

The analysis period was limited by data availability: data for all covariates were not widely available before 1980 and outcome data were not available after 2013. Before 2013, there was low missingness overall in the data for all outcomes (additional detail in Appendix C), with the exception of Oman (exposed), which had data from only 1990 onwards and Ethiopia (unexposed), which had data beginning only in 1993. These countries were excluded from the analysis in the years before they had available data; the impact of this censoring was explored in a sensitivity analysis.

Indicators

All outcome variables were measured in units of grams per capita (tobacco) or kilograms per capita (all other outcomes); for tobacco and alcohol, this was restricted to the population aged 15 and older, a standard age group for evaluating consumption of these products globally (18)(142). Key confounders established by the existing literature on the relationship between trade liberalization and NCD risk factors were controlled for in all models: GDP per capita, the proportion of the population living in an urban area (urbanization rate), and the female labor force participation rate among women aged 15 and older (full- or part-time employment in the formal or informal sector) (26)(85). Models for alcohol consumption included the proportion of each country's population identifying as Muslim as an additional covariate because countries with a higher percent Muslim population have lower rates of alcohol use overall (143). Models for tobacco

consumption included a variable indicating whether each country had ratified the FCTC because this represents a commitment to implement policies to curb tobacco use, which may impact consumption (144).

Of the outcome data series, trends for tobacco were very erratic and the following adjustments were made to reduce extreme fluctuations unlikely to reflect true changes in consumption. First, 20 country-years in which tobacco values were less than 0 were replaced as missing. Second, tobacco data were smoothed using a three-year moving average, which replaces each annual value with the mean of the values in that year and one year preceding and following. This is a common technique for reducing fluctuations in time-series data (145). All other outcome data were unadjusted.

Two covariates had significant missingness: the FLFP rate, before 1990, and percent Muslim, which was only available in 1990 and 2010. Missing values of the FLFP rate were filled using a linear backward projection based on the trend between 1990 and 2014; the assumption of linearity was based on the observation of generally linear trends in countries with complete data. Missing values of percent Muslim were filled using linear interpolation and projection, based on the trend between 1990 and 2010; the assumption of linearity was based on research on trends in national religious composition (120). Per capita values taken from all sources were normalized using UNPOP estimates to eliminate any variation due to discrepancies in population estimates.

Propensity score weights

A universal limitation of observational data is the non-random assignment of the exposure to units in the exposed and unexposed groups, which often creates imbalance in covariates and baseline measures of outcomes between the two groups (121).

Characteristics of the exposed and unexposed groups in the first (1980) and last (1995) years of the pre-exposure period are presented in Table 3.2. Although no differences were statistically significant, to further improve the comparability of the exposure groups, propensity score weights were estimated and applied in two steps, described below. This process was separate for each of the nine outcomes to generate outcome-specific weights that maximized comparability on pre-exposure values of each outcome.

Table 3.2. Baseline characteristics and tests for significant group differences between exposed and unexposed groups in the first (1980) and last (1995) years of the pre-exposure period.
Standardized difference in means = (unexposed group mean – exposed group mean)/(combined standard deviation).

	Exposed Group (n=21)	**Unexposed Group** (n=26)	**Standardized difference in means** *(p-value)**
Covariates			
Region (n)			*(0.55)*
East Asia & Pacific	4	8	
Europe & Central Asia	10	7	
Latin America & Caribbean	2	1	
Middle East & North Africa	3	5	
North America	0	0	
South Asia	1	1	
Sub-Saharan Africa	1	4	
Former USSR member state (n)	8	7	*(0.41)*
GDP per capita (2005 Int. $) (mean (SD))			
1980	5,565 (8,314)	6,907 (9,697)	0.15 *(0.69)*
1995	4,805 (4,845)	6,357 (11,005)	0.18 *(0.55)*
Female labor force particip. rate (%) (mean (SD))			
1980	44.1 (25.1)	42.1 (26.0)	-0.08 *(0.82)*
1995	51.9 (18.3)	46.5 (22.4)	-0.26 *(0.37)*
Population living in urban area (%) (mean (SD))			
1980	38.2 (20.6)	37.2 (21.9)	-0.05 *(0.90)*
1995	53.1 (20.1)	45.8 (20.9)	-0.35 *(0.23)*
Muslim population (%)** (mean (SD))			
1980	30.0 (40.4)	36.0 (43.4)	0.14 *(0.70)*
1995	22.4 (36.2)	41.8 (42.8)	0.48 *(0.11)*
Outcomes (in pre-exposure years)			
Tobacco (grams/capita, 15+) (mean (SD))			
1980	1890 (1532)	2182 (1997)	0.16 *(0.67)*
1995	1358 (1045)	1913 (2716)	0.26 *(0.38)*
Alcohol (kg/capita, 15+) (mean (SD))			
1980	25.2 (36.9)	29.8 (33.0)	0.14 *(0.72)*
1995	29.2 (26.2)	26.3 (27.5)	-0.11 *(0.71)*

Fruits and vegetables (kg/capita) (mean (SD))			
1980	108.9 (74.7)	165.8 (93.0)	0.64 (*0.09)*
1995	137.1 (61.1)	159.0 (113.2)	0.23 *(0.43)*
Nuts, seeds, and legumes (kg/capita) (mean (SD))			
1980	6.0 (3.5)	7.9 (6.2)	0.36 *(0.34)*
1995	4.4 (2.6)	6.4 (6.7)	0.38 *(0.19)*
Seafood (kg/capita) (mean (SD))			
1980	7.7 (6.8)	17.0 (17.8)	0.62 (*0.09)*
1995	9.5 (8.9)	13.9 (18.6)	0.30 *(0.32)*
Red meats and anim. fats (kg/capita) (mean (SD))			
1980	28.0 (32.2)	27.2 (18.2)	-0.03 *(0.93)*
1995	37.3 (23.8)	28.7 (20.9)	-0.38 *(0.20)*
Starches (kg/capita) (mean (SD))			
1980	193.1 (37.2)	223.0 (52.1)	0.62 *(0.10)*
1995	215.5 (55.4)	207.8 (53.3)	-0.14 *(0.63)*
Sugars (kg/capita) (mean (SD))			
1980	24.4 (14.8)	23.9 (14.1)	-0.04 *(0.93)*
1995	23.2 (8.9)	21.5 (13.1)	-0.15 *(0.61)*
Edible oils (kg/capita) (mean (SD))			
1980	6.1 (4.5)	6.8 (4.4)	0.15 *(0.70)*
1995	7.3 (4.8)	8.3 (5.5)	0.19 *(0.52)*

**Results from two-sided t-tests presented for continuous variables; results from chi-squared tests presented for categorical variables*
***Covariate used in alcohol models only*

In the first step, propensity scores for each outcome were estimated to predict the probability of exposure (WTO membership) as a function of annual values of the outcome, between 1980 and 1995, before any exposed country joined the WTO (the pre-exposure period). Propensity scores were estimated with a generalized boosted regression modeling (GBM) approach (146), which is a nonparametric "automated, data-adaptive modeling algorithm" (147). The GBM method has the advantage that it attempts to balance missingness in predictor variables across the exposure groups (146), which was important for this analysis because data for all former USSR countries were missing before 1992.

We tested propensity score models with the following additional predictors: annual values of GDP per capita (logged), urbanization rate, FLFP rate, percent Muslim (alcohol model only); a categorical variable for major world region; and an indicator for

former USSR member (yes/no). (FCTC ratification was not tested as a predictor in tobacco models because this did not come into force until after the pre-exposure period, in 2005). We also tested, as a predictor, the combined polity score (112), which measures national political systems on a scale from highly autocratic to highly democratic, because research suggests more democratic countries are more likely to join the WTO (148). However, the distribution of this variable was highly skewed between exposure groups and because no relationship between polity and the outcomes was expected, we concluded this operates as an instrumental variable. Because inclusion of this variable led to worse balance on other factors and because it is believed to be a negligent predictor of the outcomes, we excluded it.

We achieved the best balance, or similarity, in the pre-exposure level and trend of the outcomes between exposure groups from the simplest propensity score models using only pre-exposure outcome values as predictors. The balance metric chosen to identify the optimal set of propensity scores was the mean absolute standardized difference across all predictor variables, which is commonly used (146). This achieved better balance than propensity scores based on the Kolmogorov-Smirnov statistic (the maximum vertical distance in the distribution of the outcome in each exposure group) (149).

In the second step, propensity scores were used to construct weights for each country, with all exposed units receiving a weight of 1, and unexposed units receiving a weight of p/(1-p), where p is the estimated propensity score (these weights were not time-varying). Applying weights inversely proportional to the probability of receiving the exposure each country received (as estimated by the propensity score) “results in an artificial population in which baseline covariates are independent of treatment status”

(149). This weighting estimates the average treatment effect on treated (exposed) units (the ATT); i.e., the average effect of joining the WTO for those countries that did join. Each unexposed group country was assigned a unique propensity score weight for each of the nine outcomes; figure 3.1 displays the distribution of these weights for each country.

Figure 3.1. Box plots of the distribution of propensity score weights applied to each unexposed group country.
For each country, nine propensity scores were estimated – one for each outcome.

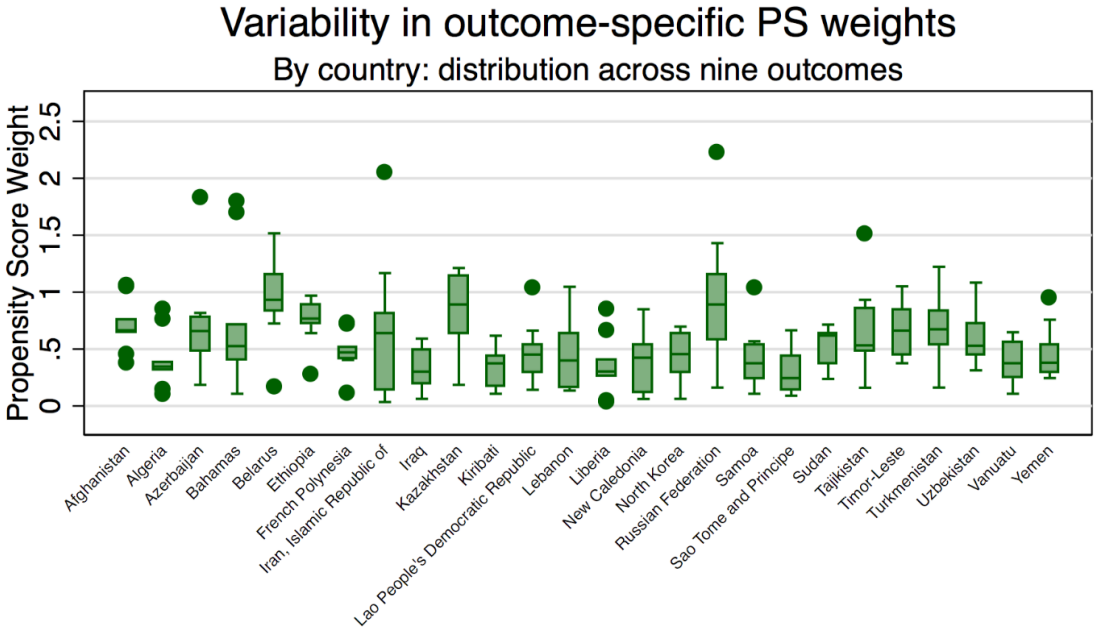
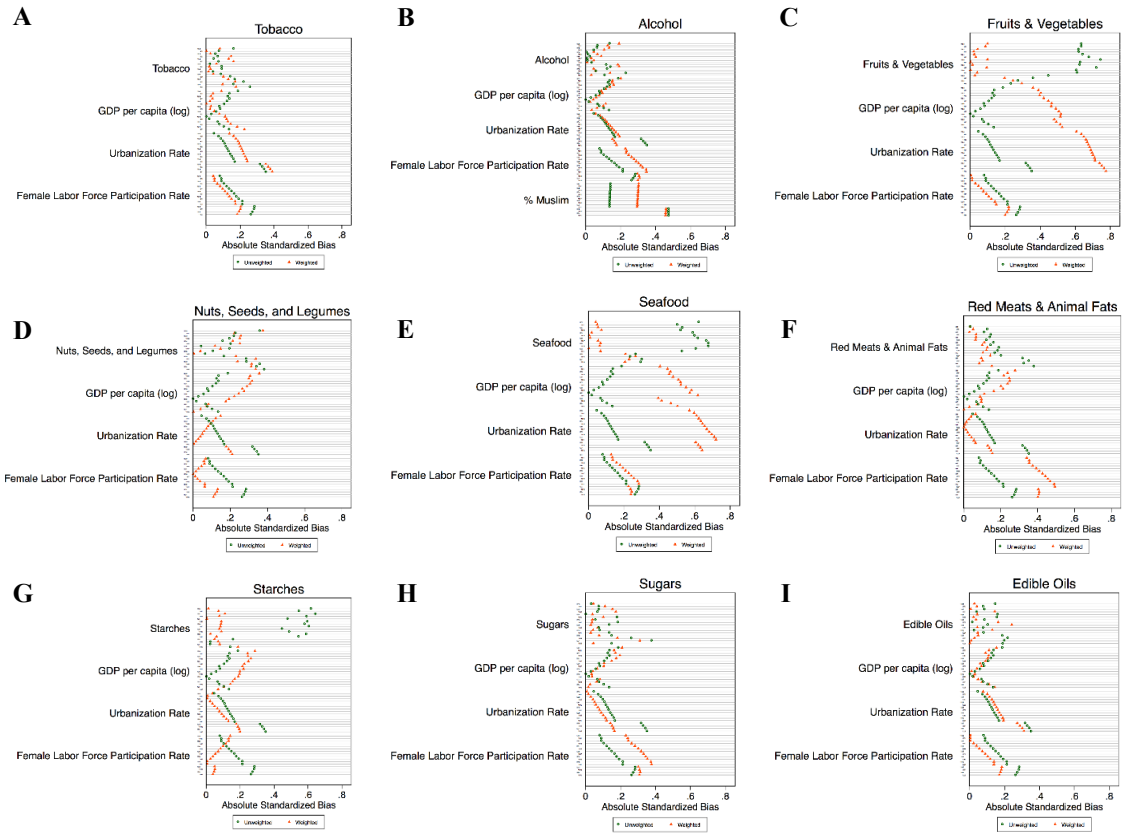


Figure 3.2 displays the balance, between exposure groups, for annual values of the outcomes and covariates during the pre-exposure period, 1980-1995, before and after applying the weights. Each individual marker represents one year of data. The metric of balance is the absolute standardized bias, which is the absolute value of the difference in unexposed and exposed group means divided by the standard deviation across both groups. A generally accepted threshold for good balance is an absolute standardized bias less than 0.25 (121).

Figure 3.2. Reduction in bias in pre-exposure (1980-1995) values of outcomes from application of outcome-specific propensity score weights:
a) tobacco, b) alcohol, c) fruits and vegetables, d) nuts, seeds, and legumes, e) seafood, f) red meats and animal fats, g) starches, h) sugars, i) edible oils.
Covariates displayed are the log of GDP per capita, urbanization rate, female labor force participation rate, and percent Muslim (alcohol only). Bias is measured by the absolute standardized mean difference (the absolute value of the difference in unexposed and exposed group means divided by the standard deviation across both groups).



In the figures, green markers indicate the unweighted balance for all variables by year, and orange markers indicate this balance after applying the propensity score weights specific to each outcome. Before weighting, balance was poorest for the outcomes fruits and vegetables, seafood, and starches, with absolute standardized bias values near or above 0.6. After applying weights, this was improved to values near or below 0.2 (closer to zero is better). For the remaining outcomes, unweighted balance was

less problematic, but improvements in balance are reflected by the general pattern of orange (weighted) markers closer to zero than green (unweighted) markers. For each of the covariates, the unweighted balance was reasonable, with absolute standardized bias values less than 0.4 for nearly all variables in all years. However, in several cases, application of weights to improve balance on outcomes sacrificed balance on covariates. Given the trade-off between imbalance in the outcomes and the covariates, we decided it was most important to maximize balance on the outcomes; the influence of the other variables is further controlled for by their inclusion as covariates in the outcome models.

Outcome models

The impacts of WTO accession were modelled using separate linear regression models for each of the nine outcomes in a comparative interrupted time-series (CITS) framework. CITS analysis relies on the inclusion of a treatment and treatment*year interaction term to compare the pre- and post-exposure level and trend in the outcome, respectively, in the exposed versus unexposed groups (122). For unexposed countries, the value of the treatment variable was always 0; for exposed countries, this ranged from 0 (before) to 1 (after), with a fraction reflecting the number of days of membership during the year of each country's accession to the WTO. Each of the outcome models had the following basic form:

$$\text{Outcome}_{ij} \sim \beta_0 + \beta_1(\text{year})_j + \beta_2(\text{treatment})_{ij} + \beta_3(\text{treatment*year})_{ij} + \beta_4(X)_{ij} + \varepsilon_{ij}$$

In this specification, i indexes country; j indexes year (1980 to 2013); X is a set of covariates; β's represent coefficients estimated by the linear model; and ε is the residual error term. All covariates were time-varying. The GDP per capita covariate was included in the model in log form because this has a more linear relationship with the outcomes.

Covariates for urbanization rate, FLFP rate, and percent Muslim (alcohol model only) were continuous, ranging from 0 to 100%. The FCTC ratification covariate (tobacco model only) ranged from 0 (not ratified) to 1 (ratified), with a fraction reflecting the number of days after ratification in the year during which each country ratified the FCTC. All models were run with outcome-specific propensity score weights applied as inverse-probability-of-treatment (IPTW) weights.

Multiple model variations were tested for each outcome; optimal models were selected based on Wald test values as well as visual inspection of graphs of model-predicted values compared to observed values. Model fit graphs are provided in Appendix D. Starting from a simple model with only the treatment variables and key control variables described above, the optimal way to model the relationship to time was examined by individually testing the inclusion of: a linear year term, year fixed effects, a quadratic term, and a cubic term. Next, three variations were tested to capture additional unexplained country-specific variation: a country random intercept, a country random intercept and random slope on time, and country fixed effects. Indicator variables for whether a country was a USSR member state and defining the period after former USSR countries' data were included (i.e., after 1992) were also explored, but neither improved model fit. To account for autocorrelation in the longitudinal data, in all models without country-specific random or fixed effects, an autoregressive structure was imposed on the residuals, chosen based on examination of the autocorrelation functions of all outcomes. In all models with a random intercept and random slope, an unstructured model was used for the covariance to permit correlation between these two parameters.

For six of the nine outcomes (tobacco; alcohol; red meats and animal fats; seafood; nuts, seeds, and legumes; edible oils), outcome values were log-transformed in order to constrain model predicted values to be greater than 0 (negative values were predicted by the untransformed models). The key output of the best-performing model for each outcome is presented in Table 3.3; additional output is provided in Appendix D.

Sensitivity analyses

Several sensitivity analyses were conducted to examine the degree to which estimated treatment effects were affected by the composition of countries included in the analysis or other aspects of the study design. First, the analysis period was restricted to 1993 to 2011 – years for which there was complete data for all 47 countries – to eliminate the influence of missing data for former USSR countries before 1992 and other missing data (e.g., Ethiopia and Oman). Second, it is plausible that changes initiated by WTO accession take time to reach full impact, so lagged values of the treatment and treatment*year terms were explored; for both variables, lags of one and two years were tested. Third, in order to examine whether the effects of joining the WTO were predominantly mediated through economic growth, GDP per capita was excluded from all models. Fourth, we excluded several countries in the unexposed group that had unique circumstances that may make them poor comparisons during the years of this analysis: North Korea (relatively isolated from the global economy, famine in 1996); Iraq (two wars); Afghanistan (war); and Ethiopia and Sudan (famines). Lastly, existing research suggests the impacts of trade liberalization may differ by national income level, so models were stratified by income group. Three groups of countries were used: high-income; upper-middle-income; and low- and lower-middle-income (combined because

there was only one low-income country in the exposed group). All analyses were conducted in Stata version 14.2, except for the *twang* package for estimating propensity scores, which was run in R version 3.3.2.

Results

Figure 3.3 displays average trends in each outcome for the exposed, unweighted unexposed, and weighted unexposed groups, with the range of years during which exposed countries joined the WTO shaded in grey (1996-2008). Trends in these three groups during the pre-exposure period, 1980 to 1995, illustrate the improved comparability in the baseline level and trend of each outcome between the exposure groups after weighting. For some outcomes, trends in the exposed and weighted unexposed groups begin to diverge during the exposure period, providing indications of possible treatment effects, which were further investigated with the outcome models.

As shown in the model output in Table 3.3, the optimal model for each outcome included a country-specific random intercept and slope. For seven outcomes, year fixed effects best captured the trend over time; for tobacco and seafood, the model with a cubic term performed best, although differences from year fixed effects models were very slight. In models with year fixed effects, a linear year term was used for the random slope; in models with a cubic fixed term, a cubic term was also used for the random slope. P-values for fixed effects are based on robust standard errors; for random effects, robust standard errors are presented.

Figure 3.3. Exposed group mean, unweighted unexposed group mean, and weighted unexposed group mean, 1980-2013, by outcome:
a) tobacco, b) alcohol, c) fruits and vegetables, d) nuts, seeds, and legumes, e) seafood, f) red meats and animal fats, g) starches, h) sugars, i) edible oils. The range of WTO accession dates for exposed countries is shaded in grey (1996-2008). Aberrations in trends starting in 1992 likely reflect the changing composition of countries in each exposure group due to data availability for former USSR countries (1992-2013 only).

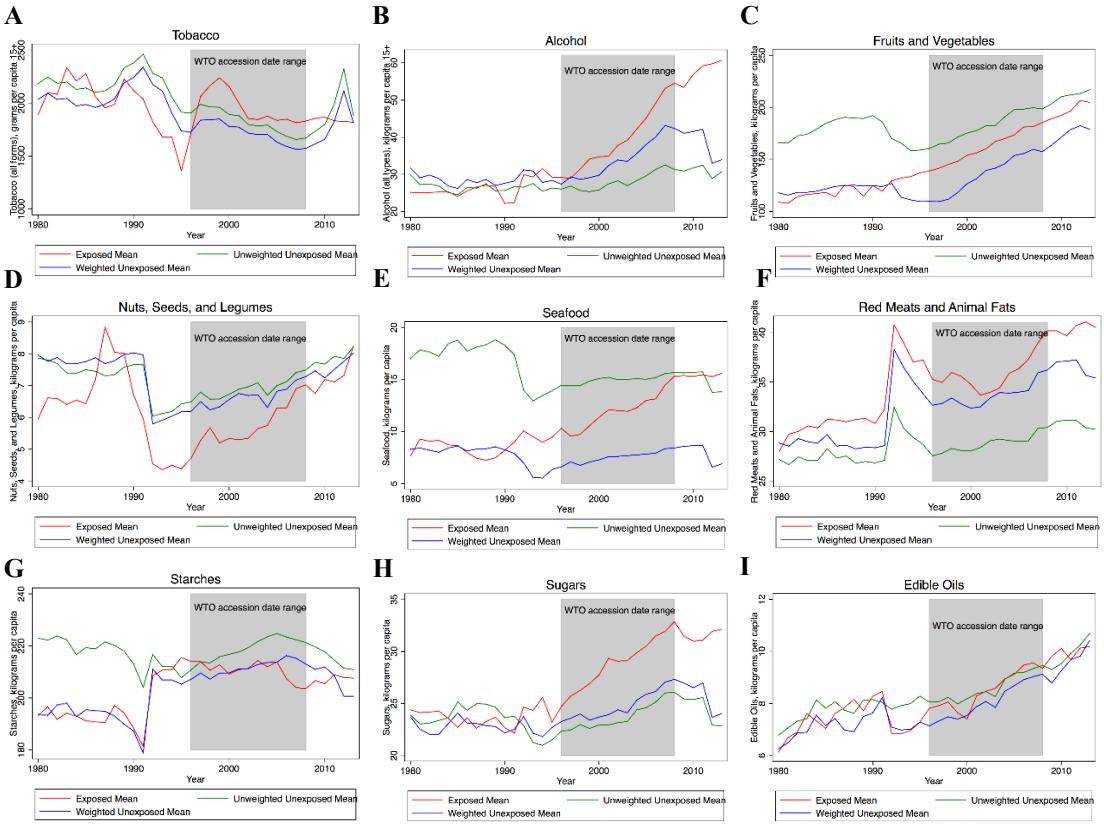


Table 3.3. Model output from best-performing model for each of nine outcomes.
Coefficients and p-values (based on robust standard errors) presented for fixed effects; variances and standard errors presented for random effects.

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.0989 *(.477)*	-0.118 *(.133)*	19.79** *(.003)*	0.107 *(.171)*	-0.137 *(.436)*	0.00831 *(.865)*	-6.277 *(.133)*	-2.401 *(.115)*	-0.0704 *(.296)*
Treatment*year	0.0605* *(.054)*	0.0370* *(.050)*	-1.276 *(.367)*	-0.0174 *(.151)*	0.0316 *(.367)*	0.00147 *(.875)*	-0.120 *(.904)*	0.250 *(.176)*	0.00526 *(.730)*
GDPpc (2005 Int $) (log)	0.449** *(.004)*	0.496*** *(<.001)*	7.571 *(.218)*	0.313 *(.060)*	0.826*** *(<.001)*	0.184* *(.020)*	5.308 *(.464)*	6.133** *(.003)*	0.150 *(.243)*
Urbanization rate (%)	-0.0166* *(.024)*	0.0141 *(.160)*	1.993** *(.004)*	-0.00456 *(.491)*	0.00607 *(.637)*	0.00401 *(.533)*	0.616 *(.189)*	0.0194 *(.879)*	0.0105 *(.052)*
FLFP rate (%)	-0.0101 *(.099)*	-0.00946 *(.202)*	-1.029 *(.069)*	-0.00108 *(.804)*	-0.0360* *(.016)*	0.00252 *(.553)*	0.298 *(.371)*	-0.133 *(.088)*	-0.0115 *(.102)*
FCTC ratification^	-0.204* *(.032)*								
Muslim population (%)^^		-0.0253*** *(<0.001)*							
Year^3	-9.72×10^{-6} *(.251)*				-1.46×10^{-6} *(.875)*				
Year fixed effects?^^^	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Constant	4.759*** *(<.001)*	-1.088 *(.337)*	7.268 *(.883)*	-1.413 *(.265)*	-3.845* *(.022)*	1.437* *(.049)*	142.4* *(.020)*	-18.94 *(.163)*	0.0659 *(.950)*
Random effects									
var(intercept)	0.944	1.659	6917	3.070	2.95	0.396	5228	87.9	8.46×10^{-4}
SE	(.199)	(.530)	(1656)	(1.58)	(.747)	(.073)	(1123)	(19.3)	(1.93×10^{-4})
var(slope)	7.83×10^{-10}	0.003	20.16	.0021	4.38×10^{-10}	2.55×10^{-4}	3.67	0.185	0.953
SE	(2.8×10^{-10})	(.0012)	(5.35)	(.0013)	(9.97×10^{-11})	(5.61×10^{-5})	(.828)	(.0367)	(.186)
cov(intercept, slope)	-1.3×10^{-5}	-0.030	-255.96	-0.0713	-1.13×10^{-5}	-0.0058	-93.4	-2.06	-.0251
SE	(4.95×10^{-6})	(.013)	(87.76)	(.0449)	(6.86×10^{-6})	(.0015)	(21.9)	(.632)	(.0061)
var(residual)	0.215	0.071	437.21	.0764	0.162	0.0177	184.2	12.29	0.0519
SE	(.046)	(.014)	(95.74)	(.0158)	(.0454)	(.0027)	(28.2)	(2.31)	(.0107)

*p<=0.05; **p<=0.01; ***p<=0.001 *^Included in tobacco model only. ^^Included in alcohol model only.*
^^^Coefficient values for individual year fixed effects not shown (when applicable); complete model output in Appendix D.

The magnitude and significance of the coefficients on the treatment and treatment*year terms indicate any difference in the level and trend, respectively, of each outcome after the exposure in the exposed versus the unexposed group. The largest observed effect is a statistically significant increase (as indicated by an intercept shift) in fruit and vegetable consumption following accession to the WTO. The coefficient on the treatment variable in this model suggests that in WTO member countries, average annual fruit and vegetable consumption is 19.79 (95% CI: 6.60 – 32.99) kg per capita higher after joining the WTO than in non-member countries. None of the treatment variables in the other models is statistically significant. The coefficients on the treatment*year terms in the tobacco and alcohol models indicate significant increasing trends in consumption following WTO accession. Taking the exponent of these coefficients (because outcomes were log-transformed) suggests that after countries join the WTO, the geometric mean of tobacco consumption increases 6.2% (95% CI: 0.00 – 13.0%) annually and the geometric mean of alcohol consumption increases 3.8% (95% CI: 0.01 – 7.7%) annually.

The coefficient on GDP per capita was positive and significant in models predicting consumption of tobacco; alcohol; seafood; red meats and animal fats; and sugars; and not statistically significant in the other models. The urbanization rate was only a significant predictor of tobacco consumption (negative) and fruit and vegetable consumption (positive). The FLFP rate coefficient was significant only for seafood consumption (negative). In the tobacco model, the coefficient on FCTC ratification was significant, indicating an 18.5% (95% CI: 1.8 – 32.4%) lower geometric mean of tobacco consumption in countries after ratifying the FCTC. In the alcohol model, the percent of the population identifying as Muslim was significant and corresponded to a 2.5% (95%

CI: 1.3 – 3.7%) lower geometric mean of alcohol consumption for every 1% increase in the population that is Muslim. For all outcomes, the confidence interval of the random intercept and random slope excluded zero, indicating substantial remaining heterogeneity across countries in both the level and trend in consumption.

The results of sensitivity analyses, (i.e., restricting the years to 1993 to 2011, excluding GDP per capita as a covariate, removing five countries that may be poor comparators, and using 1- and 2-year lags of the treatment variables) all supported the main findings, with some changes in the magnitude and significance of estimated coefficients. The treatment effect on fruit and vegetable consumption was very robust to each of these variations – the magnitude of the coefficient varied slightly but remained statistically significant. The coefficient on the trend in alcohol consumption stayed of a consistent magnitude and remained significant in most variations. The coefficient on the trend in tobacco consumption also remained of a fairly consistent magnitude, but the significance fluctuated just above and below the 0.05 alpha level. In only the lagged effect models, treatment effects for sugar were significant and similar in magnitude to those in the main model, providing some evidence of an initial decrease in sugar consumption following WTO accession, followed by a minimal steady increase.

Larger changes were seen when the analyses were stratified by country income group; these results did not support any of the main conclusions and instead, there were a few alternative significant treatment effects that varied across income groups. However, the propensity score weights applied to all models were generated to balance the sample as a whole and likely generated spurious results from these models, which were run with

23 countries or less (out of the total 47) per income group. Key model output from each of the sensitivity analyses is provided in Appendix D.

Discussion

Across several alternative model specifications and sensitivity analyses explored for each outcome, three effects were fairly robust to all variations. Following a country's accession to the WTO, there was a significant increasing trend in alcohol consumption; a borderline significant increasing trend in tobacco consumption; and a significant immediate (within the first year after joining) increase in fruit and vegetable consumption, compared to non-member countries. A plausible mechanism provides a common explanation for the finding that both tobacco and alcohol consumption increased steadily over time: upon WTO accession, countries lower import tariffs, likely facilitating the entry of a new variety of tobacco and alcohol products. Use of both of these products is addictive (150) and influenced by social norms (151)(152), which supports the plausibility of steady increases in consumption as individual and communal habits change over time.

The finding that fruit and vegetable consumption increased fairly immediately following WTO membership may also plausibly be explained by import tariff reductions, which could flood markets with produce from other WTO members, particularly in countries where domestic production is low in quantity or variety. One feasible explanation for the inconsistent and weak finding that sugar consumption initially declined and then steadily increased is that new member countries may increase their exports of sugar crops in response to lower tariffs among other WTO members importing

these products; and that new members' imports and production of processed foods and beverages, high in added sugars, gradually increase over time as these products gain popularity. However, it is not clear why similar patterns to either those observed for fruits and vegetables or for sugar would not be observed for other categories of agricultural products, for which no significant treatment effects were found. Future research could examine more detailed categories of agricultural products, i.e., by specific crops, to further investigate variations in patterns.

The changes observed in this analysis have both positive and negative implications for global health. The finding of increasing alcohol consumption requires further understanding as it is the distribution of consumption that is most critical for public health. If these increases reflect a greater number of people consuming any or a moderate amount of alcohol, there are no major negative health concerns. However, if increases reflect a segment of the population consuming alcohol in excess of recommended amounts, this can contribute to the incidence of a number of NCDs, including cirrhosis and liver cancer, as well as substance abuse disorders and alcohol-related accidents and injuries (153). In contrast, any increase in tobacco consumption is decidedly negative for public health, given that tobacco contributes to a vast number of NCDs, including chronic obstructive pulmonary disease, heart disease, and several types of cancers, and is one of the leading causes of death worldwide (154). These effects accrue to the users of these products as well as to family members and others through the impacts of second-hand smoke (155). Furthermore, if increases in tobacco and alcohol consumption predominantly reflect growth in foreign versus domestic brands, any indirect health benefits from economic growth will primarily accrue in other countries

where corporations owning these brands are headquartered. In contrast, increases in fruit and vegetable consumption have many positive implications for public health since fruits and vegetables protect against the development of several NCDs (138). The estimated amount of this increase – approximately 20 kg per person per year – is equivalent to 100 days' intake of 200 grams of fruits and vegetables, or two and a half standard portions, per person, an amount proven to reduce the risk of several NCDs and premature mortality (156).

The graphs in Figure 3.3 suggest the presence of some treatment effects that were not supported by the outcome models. There appear to be dramatic increases in seafood and sugar consumption and a slight increase in red meat and animal fat consumption in exposed countries compared to the weighted unexposed countries. However, the graphs may also be misleading because the *range* of WTO accession dates is shaded, but countries joined at different times during this period, so trend changes early in the exposure window may be occurring before WTO accession in one or more countries. Another possible explanation of these discrepancies between the graphical and statistical results is that the observable changes are predominantly explained by one or more of the covariates, which may be changing independently or operating as mediators of the relationship between WTO membership and changes in consumption. However, removing GDP per capita, which was a significant predictor in most models, did not lead to new significant treatment effects. An alternate possible explanation is that the models were not sufficiently well fit to the data to detect these effects. Many model variations were tried, but none perfectly fit the data, which were in many cases fairly erratic.

The treatment effects indicated by the graphs and models explored in this analysis are suggestive but not conclusive, warranting additional exploration. One next step would be to recreate this analysis using only one country income group (low, middle, high) at a time, generating weights to balance pre-exposure outcome trends by income group. It is plausible that the effects of WTO membership differ greatly by level of economic development and by other country-specific factors, such as geography and climate, which affect the baseline supply of various food groups, tobacco, and types of alcohol. The large variability in country-specific random effects in all models supports the conclusion that additional country-level factors in part explain observed trends.

Findings from this analysis both confirm and conflict with selected findings of previous research. Studies identifying increases in consumption of meat (55)(57) and edible oils (157) following trade liberalization were not confirmed by this analysis. Discrepancies may be due to differences in the countries included; these previous studies examined only one to five countries in the same region. Studies that have identified trade-related increases in SSB consumption (63)(61) were somewhat supported by the weak finding that sugar consumption increases steadily over time following WTO accession. However, sugars are used in many products besides SSBs, so this outcome is much less specific than SSBs, possibly explaining why findings were not entirely consistent. Previous analyses finding increased tobacco (66)(65) and alcohol (26) consumption associated with trade liberalization were confirmed. Finally, very few existing studies appear to have examined fruit and vegetable consumption in the context of either trade or investment policies, but these findings support the conclusion of a previous analysis that

identified an increase in imported fruit consumption in five Central American countries following changes in trade policies (57).

Although WTO accession is broadly comparable across countries, it is a negotiated process and the specific concessions agreed to by each joining member differ. Countries may negotiate greater protections for industries vital to their economies in the form of higher import tariffs on key products. Such variations in tariff and non-tariff barriers by countries and products likely explain some of the inconclusive effects on consumption levels following WTO accession. Exploration of these individual variations is beyond the scope of this analysis but is an important area for future research to better understand the mechanisms of these changes and to identify possible policy responses to curb increases in NCD risk factors.

Limitations

A primary limitation of this study is the comparability of countries joining versus not joining the WTO, which is necessary to fulfill the fundamental assumption underlying CITS analysis: that trends in the exposed group would resemble trends in the unexposed group in the absence of the exposure. Differences in trends could be due to innate characteristics of countries in either group or the influence of exogenous events that occurred during the analysis period, such as the entry into force of any regional (bilateral or multilateral) trade or investment agreements. These and other major events (aside from FCTC ratification) that may have occurred in countries in either exposure group were not accounted for.

Exploration of baseline covariates in both exposure groups suggested that, in general, exposed countries had larger populations, lower per capita incomes, greater

proportions of women participating in the labor force, larger proportions of the population living in urban areas, and less of the population identifying as Muslim. The use of propensity score weighting improved balance in the outcomes across the two groups of countries, but in some cases sacrificed balance on these covariates. Even post-weighting, the percent of the population identifying as Muslim was not well-balanced between the exposure groups and could contribute to the observed treatment effect on alcohol consumption. As shown in Figure 3.1, weights for the nine unexposed countries that joined the WTO in the final two years or after the analysis period (Afghanistan, Kazakhstan, Lao People's Democratic Republic, Liberia, Russian Federation, Samoa, Tajikistan, Vanuatu, and Yemen) were not consistently higher than those for countries that have not yet joined the WTO. This suggests that WTO members (the exposed group) were not systematically more similar to future WTO members than continuing non-members, supporting a causal interpretation of any changes in the outcomes after WTO accession.

Another key limitation is the quality of the outcome data, which were taken from the FAO food and commodity balances. This data source measures the available supply of each commodity, which is a proxy for consumption, but due to unmeasured waste or other intervening factors, may not accurately depict changes in consumption. In addition, there was substantial missingness in the data for certain items summed to create outcome variables (highest for selected items of seafood; sugars; nuts, seeds, and legumes; and edible oils), which may affect the validity of data for these categories. These data are also somewhat erratic over time, which made it challenging to fit accurate models that may have precluded the detection of significant relationships between the policy change and

the outcomes. Finally, for tobacco and alcohol, illicit sales and homemade varieties are not captured in this data, which may comprise substantial portions of consumption in certain countries.

Conclusion

Using a natural experiment design, strengthened by the use of propensity score weights to improve the comparability of two exposure groups, this analysis explored the impact of joining the WTO on national trends of several key NCD risk factors. The findings suggest that following accession to the WTO, countries experience an immediate increase in fruit and vegetable consumption of approximately 20 kg per capita per year and annual increases in tobacco and alcohol consumption – approximately 6% and 4% of the geometric means, respectively. No significant impacts were found on consumption of red meats and animal fats; seafood; nuts, seeds, and legumes; starches; or edible oils. Conflicting results for sugar consumption were observed. Results from the model predicting tobacco consumption also suggest that ratification of the FCTC is associated with significantly lower tobacco use. These changes have important implications for public health, particularly for the development and prevention of NCDs, via the harmful effects of tobacco and alcohol consumption and the protective effects of fruit and vegetable consumption. Overall, findings were not strongly conclusive of consistent effects across countries and regression results indicated substantial remaining country-level heterogeneity in impacts. Additional exploration of variations in these impacts across countries is critical to identify factors that mitigate the negative role and enhance

the positive role of global trade and investment liberalization in the global NCD epidemic.

Chapter 4: The impact of U.S. free trade agreements (FTAs) on processed food sales, 2002-2016: a natural experiment comparing ten countries joining U.S. FTAs with matched comparison countries (Aim 2)

Abstract

Countries joining a free trade agreement (FTA) with the U.S. commit to reduce import barriers to U.S. goods and services, including the highly-processed products of U.S.-based transnational food and beverage corporations, regular consumption of which can contribute to the development of non-communicable diseases (NCDs). This study uses a natural experiment design to assess changes in sales of processed foods and beverages, between 2002 and 2016, in ten countries joining U.S. FTAs compared to 11 countries without a U.S. FTA in force. Exposed and unexposed countries are matched on national income level, major world region, and World Trade Organization (WTO) membership status. Annual country-level data for all outcomes come from the Euromonitor International Global Market Information Database. Analyses are conducted in a comparative interrupted time-series framework using multivariate random-effects linear models, adjusted for known key confounders: gross domestic product (GDP) per capita, the percent of the population living in an urban area, and the female labor force participation rate. Membership in other FTAs and investment treaties are also tested as possible confounders. Results indicate that after countries join a U.S. FTA, sales of ultra-processed products, processed culinary ingredients, and baby food all increase annually.

A slightly declining trend is found for the ratios of sales of fresh versus processed meat and seafood and fresh versus processed fruits and vegetables. No change is found in sales of minimally processed foods. In statistical models, large variations in country-specific random intercepts and slopes are estimated, suggesting that additional unmeasured country-level factors also impact sales of these products following entry into a U.S. FTA. These findings strongly support the conclusion that entry into a U.S. FTA leads to detrimental changes in national dietary consumption that increase population risk of NCDs.

Introduction

Recent patterns of global dietary change, deemed the "nutrition transition," are characterized by a progressive shift from diets high in complex carbohydrates and fiber towards greater consumption of edible oils, animal fats, and sugars, particularly in the form of more processed foods (20)(17). These changes contribute to obesity and associated non-communicable diseases (NCDs). Dietary risks, particularly low consumption of whole grains and fruits, and high sodium consumption, are leading determinants of morbidity and mortality worldwide (127)(17). In addition to the macro- and micro-nutrient content of changing diets, the degree of processing of foods and beverages is the focus of increasing attention and concern (158)(159). Diets characterized by significant consumption of highly-processed products have been found to be nutritionally inferior (160), have higher levels of added sugars (161), and are associated with higher body mass index (BMI) (162).

For infants' diets, exclusive breastfeeding for six months and complementary feeding until two years of age are widely acknowledged to be optimal for health (163). In recent years, rates of exclusive breastfeeding have remained suboptimal and relatively stable worldwide, while milk formula sales grew by over 40% between 2008 and 2013 (164). Concern over the inappropriate replacement of breast-milk with substitute foods led to the creation of the International Code of Marketing of Breast-milk Substitutes by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) in 1981 (165). This code aims to limit advertising and promotion of breast-milk substitutes, which may detract from messages emphasizing the importance and benefits of breastfeeding, but violations persist widely (166). Poor nutrition at early ages

– from reduced rates of breastfeeding in infancy to greater consumption of energy-dense, nutrient-poor food in early childhood – are key contributors to childhood obesity (167), which is increasing worldwide (168).

A common trait of highly-processed foods, beverages, and infant formulas is that most of these are produced, marketed, and sold by transnational corporations, and U.S. companies play a dominant role in each of these industries. Nine of the ten largest transnational food and beverage corporations (TFBCs) (excluding alcohol producers) are U.S. companies (169). The food service sector, which sells many highly-processed products, is also dominated by U.S. companies, four of which are the largest in this sector and account for 25% of global sales (128). Two of the four leading global manufacturers of infant foods, which represent over half of this market, are also U.S. companies (164). In 1981, the U.S. was the only country to vote against the International Code of Marketing of Breast-milk Substitutes, a position presumably driven by industry pressure (166).

New trade and investment agreements, which reduce barriers to the movement of goods, services, and capital across national borders (170), create market opportunities for TFBCs by facilitating the entry, manufacturing, advertising, and sale of products in previously untapped markets. In addition to its relationships through the World Trade Organization (WTO), the U.S. currently has bilateral or multilateral free trade agreements (FTAs) (some of which also cover investment), with 20 countries, which entered into force between 1985 and 2012 (114), and bilateral investment treaties (BITs) with 41 countries (115). The recent trend in FTAs is toward the inclusion of an increasing number of investment provisions, resulting in single comprehensive agreements that substantially

liberalize both trade and investment. The decision by two countries to establish a trade or investment treaty is somewhat idiosyncratic and can be influenced by a variety of factors, including geographic proximity, strategic interests, and domestic and international politics; in the U.S.'s case, partner countries have often initiated the treaty negotiation process (171).

Previous research examining relationships between U.S. trade and investment agreements and consumption of processed foods and beverages found consumption of sugar-sweetened beverages (SSBs) is 60% higher in countries with a U.S. FTA compared to countries without a U.S. FTA (26). However, a separate examination of SSBs in Peru following its ratification of a U.S. FTA found no significant difference in sales compared to Bolivia, which has no U.S. FTA (62). The present study utilizes a natural experiment design to examine these relationships for a greater diversity of highly-processed foods and beverages in a set of countries over time. Natural experiments utilize observational data to mimic the conditions of a randomized experiment, by taking advantage of a change in policy or other exogenous factor, to assess any observable differences in units with versus without the change (96). This is the first analysis to examine longitudinal trends in several processed food outcomes in multiple U.S. FTA partner countries, and one of only a few analyses to use a natural experiment design to assess the impacts of trade agreements (62)(63)(64).

We assess changes in sales of processed foods and beverages, including infant foods, in countries joining a U.S. FTA compared to a set of matched unexposed countries with no U.S. FTA in force. We hypothesized that, following entry into force of a U.S. FTA, sales of ultra-processed products, processed culinary ingredients, and baby foods

increase; sales of minimally processed foods decrease; and the ratios of sales of fresh versus processed meat and seafood and fruits and vegetables decrease, in U.S. FTA partner countries compared to non-U.S. FTA partner countries.

Methods

Study Design

Using a comparative interrupted time-series (CITS) framework, this study compares outcomes in 21 countries, from 2002 to 2016: ten countries joining a U.S. FTA between 2004 and 2012 (exposed group) (Table 4.1) and 11 matched countries without a U.S. FTA as of 2016 (unexposed group). Of 20 total countries with U.S. FTAs currently in force, ten were excluded due to a lack of data: three (Israel, Canada, Mexico) joined a U.S. FTA before the period when data were available and seven (El Salvador, Honduras, Nicaragua, Bahrain, Oman, Jordan and Panama) are not included in the dataset used for this analysis. The post-exposure period in each exposed country was defined as beginning on the date of entry into force of its U.S. FTA. The treaty negotiation process can last several years, but the date of entry into force reflects the time when provisions become enforceable and is therefore most meaningful as the exposure date for this analysis (113).

Table 4.1. Countries in exposed group, with date of entry into force of U.S. free trade agreement (FTA).

Country	US FTA: date of entry into force*
Chile	January 1, 2004
Singapore	January 1, 2004
Australia	January 1, 2005
Morocco	January 1, 2006
Guatemala	July 1, 2006
Dominican Republic	March 1, 2007
Peru	February 1, 2009
Costa Rica	January 1, 2009
Republic of Korea	March 15, 2012
Colombia	May 12, 2012

**Dates from: https://ustr.gov/trade-agreements/free-trade-agreements*

Six primary outcomes were examined: total sales of 1) minimally processed foods, 2) processed culinary ingredients, 3) ultra-processed products, and 4) baby food; and the ratio of sales of fresh versus processed 5) meat and seafood and 6) fruits and vegetables. The three outcomes defined by degree-of-processing utilize the classification scheme developed by Monteiro, et al., which categorize products based on the "extent and purpose of food processing" (172). This defines three distinct categories: unprocessed or minimally processed foods, processed culinary ingredients, and ultra-processed ready-to-eat or ready-to-heat products. While these outcomes have clear health implications (more processing is worse), changes in the ratio of sales of fresh versus processed fruits and vegetables could be both positive and negative for health, e.g., processing may introduce unhealthy additives such as salt and sugar, but may also reduce the risk of spoilage, increasing food safety. Furthermore, the two outcomes defined by the ratio of sales provide indications of changes in purchasing habits overall. Table 4.2 lists the six outcomes and the data elements summed to generate each; the three degree-of-processing categories were generated from this dataset using an approach from the empirical literature (173).

Table 4.2. Composition of study outcomes.

Outcome	Data elements*
Total sales	
Minimally processed foods	eggs; fish and seafood; fruits; meat; nuts; pulses; starchy roots; vegetables
Processed culinary ingredients	butter and margarine; drinking milk products; oils and fats; other dairy; processed fruits and vegetables; rice, pasta, and noodles; sugar and sweeteners
Ultra-processed products	baked goods; breakfast cereals; cheese; chocolate confectionary; ice cream and frozen desserts; processed meat and seafood; ready meals; sauces, dressings, and condiments; savory snacks; soup; spreads; sugar confectionary; sweet biscuits, snack bars, and fruit snacks; yogurt and sour milk products; carbonates; concentrates; juice; ready-to-drink coffee; ready-to-drink tea; sports and energy drinks
Baby food	baby food (milk formula, prepared, dried and other baby food)
Ratio of total sales	
Fresh/processed meat and seafood	meat (fresh foods), fish and seafood (fresh foods); processed meat and seafood (packaged foods)
Fresh/processed fruits and vegetables	fruits (fresh foods), vegetables (fresh foods); processed fruits and vegetables (packaged foods)

**Definitions of individual product categories (from Euromonitor International) are provided in Appendix E*

Data Sources

Data for all outcomes come from the Euromonitor International Passport Global Market Information Database (GMID), 2017 edition, which reports annual retail sales volumes for a wide range of products, based on data compiled from company reports, industry publications, government statistics, and interviews (103). This dataset is widely used in studies exploring national, regional, and global dietary trends as a proxy for consumption (26)(62)(63). The database currently covers 80 countries and is annually updated to provide historical estimates for the last 15 years (data for 2002-16 were available at the time of this study).

Covariate data are from the World Bank World Development Indicators (104) (female labor force participation rate), the United Nations Population Division (UNPOP)(106) (total population, population under age five, and urbanization rate), the

Institute for Health Metrics and Evaluation (IHME) (141) (GDP per capita), and the International Monetary Fund (IMF) World Economic Outlook Database (110) (GDP per capita in 2016). Information on membership in trade and investment agreements was obtained from: the Office of the U.S. Trade Representative (114) (US FTAs), the World Trade Organization (29) (WTO membership), the U.S. Office of Trade Agreements Negotiations and Compliance (115) (US BITs), the European Commission (118) (European Union (EU) FTAs), the Switzerland State Secretariat of Economic Affairs (119) (Switzerland FTAs), and the United Nations Conference on Trade and Development (174)(175) (EU international investment agreements (IIAs) and Switzerland BITs).

Indicators

Minimally processed foods, processed culinary ingredients, and ultra-processed products were measured in kilograms per capita. Sales volumes for all beverages were summed with foods assuming the density of water (1 kilogram per liter). Baby food was measured in kilograms per capita under the age of five. The outcomes fresh versus processed meat and seafood and fresh versus processed fruits and vegetables were measured with a single number reflecting the ratio of total sales of the numerator (fresh products) versus the denominator (processed products).

Key confounders established by the existing literature on the relationship between trade and investment liberalization and dietary consumption were included as covariates in all models: gross domestic product (GDP) per capita, the proportion of the population living in an urban area (urbanization rate), and the female labor force participation (FLFP) rate among women aged 15 and older (full- or part-time employment in the

formal or informal sector). Economic growth (GDP per capita), urbanization, and female labor force participation likely impact food environments in the same direction as trade and investment liberalization; the coefficients for these covariates were expected to behave similarly to those for treatment variables. Possible confounding due to membership in the following key trade and investment agreements was also explored: U.S. BIT, EU FTA, EU IIA, Switzerland FTA, and Switzerland BIT. Membership in a U.S. BIT is a potential confounder because these agreements liberalize investment opportunities for U.S. corporations, which may impact sales of processed foods and beverages through similar mechanisms as liberalized trade and investment from FTA provisions. Likewise, FTAs, BITs, or IIAs with the EU or Switzerland may have similar effects because the majority of other leading TFBCs are based in one of these countries.

Most product groups summed to generate the outcome variables had complete data for all countries and years included in this analysis. Data were missing for the following products, all of which are components of the ultra-processed products outcome: ready meals (Tunisia, 2002-06), concentrates (Peru, all years; Bolivia, all years; Colombia, 2002-05, 2014-16; Korea, 2002-05), ready-to-drink coffee (various years for 15 countries), ready-to-drink tea (various years for eight countries), sports and energy drinks (Tunisia, 2002-04). Missingness for ready meals, concentrates, and sports and energy drinks was not accounted for because these individual products contributed less than 0.3% to the outcome in these countries in years without missing data; and less than 0.8% across all countries in cases where no data were available for a country for that specific product (concentrates in Peru and Bolivia). Missingness in ready-to-drink coffee and ready-to-drink tea, which contributed 4.5-10.6% and 5.3-9.0% to the total across all

countries in each year, respectively, was also not accounted for in primary analyses, but the impact of excluding these product categories was explored in sensitivity analyses.

Data for selected product groups were labeled by Euromonitor as "modelled" for seven countries (exposed group: Costa Rica, Dominican Republic, Guatemala; unexposed group: Bolivia, Ecuador, Tunisia, Uruguay). This designation applies to: all products in the minimally processed foods outcome; the fresh food components of the two fresh/processed ratio outcomes; sugar and sweeteners, a component of the processed culinary ingredients outcome; and ready-to-drink coffee, in the ultra-processed products outcome. Modelled data were treated the same as all other data, but in sensitivity analyses the impacts of excluding countries with any modelled data were explored.

Baby food data for Hong Kong were noted to have implausibly high values, particularly beginning in 2008, when the value is more than six times higher than the mean for all other countries in the dataset. This discrepancy continues to increase through 2016, when the Hong Kong value is more than 11 times greater than all other countries' average. This increase coincides with an epidemic of infant deaths in China due to tainted infant formula (176), after which demand surged for alternative brands available in Hong Kong, which were purchased and transported to China for resale (177). Thus, data from Hong Kong were excluded for all analyses of baby food since this increase likely does not reflect true changes in consumption in Hong Kong.

The chosen GDP estimates (IHME) were preferred because the constant international dollar series controls for inflation over time and differences in purchasing power parity across countries (108). These data were not available for 2016, which were estimated using a supplementary source (IMF) (110). The relationship between IHME

GDP per capita, in constant international dollars, and IMF GDP per capita, in current international dollars (not adjusted for inflation), was modeled with simple linear regression, by country, in 2014 and 2015. This model was used to predict values for GDP per capita in constant international dollars in 2016 based on each country's 2016 GDP per capita in current international dollars. UNPOP estimates (106) were used as denominators of all per capita values (outcomes and GDP).

Matching

A limitation of natural experiments is the non-random assignment of the exposure to exposed and unexposed units, which often creates imbalance in covariates and baseline measures of outcomes between the exposure groups; i.e., countries that choose to enter into a U.S. FTA may differ from those that don't (121). Matching is one technique that can improve comparability across the groups and strengthen conclusions about causality, in addition to the strengths of the CITS modeling framework for causal inference (122). Coarsened exact matching (CEM) is a matching approach that allows researchers to coarsen selected variables into meaningful groups, identify exact matches on the coarsened variables, and conduct analyses using only the matched units and the original (uncoarsened) data (123). A stratum is formed for each unique combination of coarsened variable values, containing all exposed and unexposed units with those characteristics. Analyses are then conducted with unexposed units weighted to reflect the number of exposed units in the stratum (unexposed weight = number of exposed units in stratum/number of unexposed units in stratum), and all exposed units receiving a weight of 1. The CEM method can discard units from both groups, if no unit in the alternate exposure group has the same coarsened variable values.

For this analysis, CEM was used to identify matches based on three variables: world region, country income level, and WTO membership status. World Bank classifications were used for region and income level, which define seven regional groups (East Asia & Pacific, Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, North America, South Asia, Sub-Saharan Africa) and four income categories (low, lower-middle, upper-middle, and high) (104). From a pool of 65 potential unexposed countries with all necessary data, 11 countries fell into one of the five strata formed by the combination of characteristics present in the exposed group. No exposed countries were discarded. Table 4.3 displays these five strata, the matched characteristics (region, income group, and WTO membership status), and the exposed and unexposed countries in each. Table 4.4 provides mean values of all outcome variables and covariates, by exposure group, in the baseline year, 2002.

Table 4.3. Exposed and unexposed group countries in each of five strata formed by coarsened exact matching (CEM).

Strata	Region*	Income group*	WTO member	Exposed group countries	Unexposed group countries
1	East Asia & Pacific	High	yes	Australia, Republic of Korea, Singapore	Japan, Hong Kong (China SAR), New Zealand
2	Latin America & the Caribbean	High	yes	Chile	Uruguay
3	Latin America & the Caribbean	Upper-middle	yes	Dominican Republic, Peru, Colombia, Costa Rica	Ecuador, Venezuela, Argentina, Brazil
4	Latin America & the Caribbean	Lower-middle	yes	Guatemala	Bolivia
5	Middle East & North Africa	Lower-middle	yes	Morocco	Egypt, Tunisia

**Region and income group based on World Bank classifications for fiscal year 2016, using gross national income (GNI) per capita in US$: low income (<=$1,025), lower-middle income ($1,026-$4,035), upper-middle income ($4,036-$12,475), high income (>$12,475) (178).*

Table 4.4. Baseline characteristics (2002) and tests for significant group differences between exposed countries and all unexposed countries and matched unexposed countries.
Matched unexposed means and counts for all variables are weighted to reflect the number of exposed countries in each strata (in some cases, weighting results in non-integer counts). Standardized difference in means = (unexposed group mean – exposed group mean)/(combined standard deviation). Bold values indicate statistically significant differences between the exposure groups.*

	Exposed (n=10)	**All Unexposed** (n=65)	**Matched Unexposed** (n=11)
Covariates (in baseline year, 2002)			
Region^ (n)			
East Asia & Pacific	3	9	3
Europe & Central Asia	0	38	0
Latin America & Caribbean	6	6	6
Middle East & North Africa	1	6	1
North America	0	0	0
South Asia	0	2	0
Sub-Saharan Africa	0	4	0
Chi-squared (p-value)		***22.2 (<.01)***	*0 (1.00)*
Income group^ (n)			
Low income	0	0	0
Lower-middle income	2	13	2
Upper-middle income	4	21	4
High income	4	31	4
Chi-squared (p-value)		*0.27 (.88)*	*0 (1.00)*
GDP per capita (2005 International $) (mean (SD))	13,490 (12,222)	14,520 (11,965)	12,980 (10,340)
Standardized difference in means (p-value)		*0.09 (.80)*	*-0.05 (.92)*
Female labor force participation rate (%) (mean (SD))	46.1 (10.6)	47.9 (13.0)	50.3 (11.3)
Standardized difference in means (p-value)		*0.15 (.67)*	*0.39 (.34)*
Population living in urban area (%) (mean (SD))	72.6 (16.6)	63.6 (17.9)	79.7 (15.6)
Standardized difference in means (p-value)		*-0.50 (.14)*	*0.44 (.30)*
WTO member^ (n (%))	10 (100%)	52 (80%)	10 (100%)
Chi-squared (p-value)		*2.4 (.12)*	*0 (1.00)*
US bilateral investment treaty in force (n (%))	1 (10%)	20 (30.8%)	4 (40%)
Chi-squared (p-value)		*1.9 (.17)*	*2.3 (.14)*
EU free trade agreement in force (n (%))	1 (10%)	7 (10.8%)	0.5 (5%)
Chi-squared (p-value)		*<.1 (.94)*	*0.25 (.62)*
EU international investment agreement in force (n (%))	3 (30%)	22 (33.9%)	4.5 (45%)
Chi-squared (p-value)		*0.1 (.81)*	*0.50 (.50)*
Switzerland free trade agreement in force (n (%))	1 (10%)	28 (43.1%)	0 (0%)
Chi-squared (p-value)		***4.0 (.05)***	*1.0 (.32)*
Switzerland bilateral investment treaty in force (n (%))	6 (60%)	33 (50.8%)	6 (60%)
Chi-squared (p-value)		*0.30 (.59)*	*0 (1.00)*
Outcomes (in baseline year, 2002)			
Minimally processed foods (kg per capita) (mean (SD))	219 (70)	216 (78)	226 (80)
Standardized difference in means (p-value)		*-0.03 (.92)*	*0.10 (.82)*
Processed culinary ingreds. (kg per capita) (mean (SD))	106 (39)	96 (52)	105 (41)
Standardized difference in means (p-value)		*-0.20 (.56)*	*-0.03 (.95)*
Ultra-processed products (kg per capita) (mean (SD))	138 (78)	168 (99)	147 (65)
Standardized difference in means (p-value)		*0.30 (.37)*	*0.13 (.77)*

****Baby food (kg per capita under 5)** (mean (SD)) *Standardized difference in means (p-value)*	5.7 (5.0)	12 (12) *0.54 (0.11)*	5.7 (4.3) *<0.01 (1.0)*
Fresh/processed meat & seafood (ratio) (mean (SD)) *Standardized difference in means (p-value)*	18 (15)	56 (238) *0.17 (0.61)*	14 (9.4) *-0.30 (.51)*
Fresh/processed fruits & veg. (ratio) (mean (SD)) *Standardized difference in means (p-value)*	87 (111)	288 (1034) *0.21 (0.54)*	53 (61) *-0.38 (.37)*

**Results from two-sided t-tests (unweighted data) and adjusted Wald tests (weighted data) presented for continuous variables; results from chi-squared tests (unweighted data) and F tests (weighted data) presented for categorical and binary variables*
^Variable used for matching
***Excludes data for Hong Kong*

Outcome Models

The impact of joining a U.S. FTA on each of the six outcomes was investigated using separate linear regression models. Comparative interrupted time-series analysis relies on the inclusion of a treatment and treatment*year interaction term to compare the pre- and post-exposure level and trend, respectively, in the exposed versus unexposed groups (122). For unexposed countries, the value of the treatment variable was always 0; for exposed countries, this value ranged from 0 (before) to 1 (after), with a fraction reflecting the number of days in force during the year each country's FTA entered into force. Each model incorporated the CEM weights and included control variables for the following key potential confounders: GDP per capita, urbanization rate, and FLFP rate. Each of the outcome models had the following basic form:

$$\text{Outcome}_{ij} \sim \beta_0 + \beta_1(\text{year})_j + \beta_2(\text{treatment})_{ij} + \beta_3(\text{treatment*year})_{ij} + \beta_4(\log \text{GDPpc})_{ij} + \beta_5(\text{urbanization rate})_{ij} + \beta_6(\text{FLFP rate})_{ij} + \varepsilon_{ij}$$

In this model specification, i indexes country; j indexes year (2002 to 2016); β's represent coefficients estimated by the linear model; and ε is the residual error term. All covariates were time-varying. GDP per capita was included in the model in log form because this has a more linear relationship with the outcomes; urbanization rate and

FLFP rate were continuous, ranging from 0 to 100%. Alternative models explored the inclusion of membership in other trade and investment agreements as additional covariates: U.S. BIT, EU FTA, EU IIA, Switzerland FTA, and Switzerland BIT. These variables ranged from 0 to 1, with a fraction reflecting the number of days in force in the year each agreement entered into force, 0 in all years before, and 1 in all years after.

Models for each outcome were built in a forward stepwise manner, starting from a model with only the treatment and control variables described above. First, the optimal way to model the relationship to time was examined by comparing the inclusion of a linear year term and year fixed effects. To account for autocorrelation in the longitudinal data, an exchangeable structure was imposed on the residuals, chosen based on the shape of the autocorrelation functions of each outcome. The best-performing models were selected based on Wald tests, as well as visual inspection of graphs of model-predicted values compared to observed values, by country. Model fit graphs are provided in Appendix F. The fit statistics and graphs both supported the year fixed effects model as preferable for all outcomes.

In the second step, three alternative sets of additional terms were tested to capture remaining unexplained country-specific variation: a country random intercept, a country random intercept and country random slope on year, and country fixed effects. In models with a random intercept and random slope, an unstructured model was used for the covariance to permit correlation between these two parameters. Graphs of model-predicted values compared to observed values supported the random intercept and random slope model as the best-performing for all outcomes.

For three of the six outcomes, the distribution was highly skewed (baby food; fresh versus processed meat and seafood; fresh versus processed fruits and vegetables), so each of the models described above was tested using the log of the outcome as well as the untransformed values. None of the models with log-transformed outcomes provided a better fit to the data. In addition, a log-normal model with the same terms as the best-performing model described above was also tested for all six outcomes, but these models did not improve fit. The key output of the best-performing model for each outcome is presented in Table 4.5; additional model output is provided in Appendix F.

Sensitivity Analyses

Two sensitivity analyses were conducted to examine the impact of modelled or missing data on the estimated treatment effects. First, three of the six outcome models were re-estimated without data from the seven countries for which any data were marked as modelled (these three outcomes were the only ones for which more than one data component was modelled). An additional country (Chile) was also excluded because its only matched unexposed country (Uruguay) was dropped; these models included six exposed and seven unexposed countries. Second, the model for ultra-processed products was re-estimated without data for ready-to-drink coffee and ready-to-drink tea because of the high missingness in these two products' data.

Another sensitivity analysis was conducted to examine the influence of Venezuela as a member of the unexposed group. Venezuela is experiencing a food shortage, which started with food rationing in 2014 (179), possibly making this a poor comparison country for these outcomes. Each of the outcome models was re-run with Venezuela excluded from the unexposed group and the remaining three countries in Venezuela's

strata up-weighted to account for its removal. All analyses were conducted in Stata, version 14.2.

Results

Figure 4.1 displays average per capita sales in exposed, all unexposed, and matched unexposed countries, between 2002 and 2016, for minimally processed foods, processed culinary ingredients, ultra-processed products, and baby food, with the range of years when U.S. FTAs entered into force marked. Differences between the means for all unexposed and matched unexposed countries in the pre-exposure period indicate improved comparability between the exposure groups after matching, with the exception of the minimally processed foods outcome, for which comparability worsened. The ultra-processed products means are also not highly similar between the exposed and matched unexposed groups in the pre-exposure period.

These trends indicate that per capita sales of each of these categories of products increased during the study period in both exposure groups, but some differences in the rates of growth are noticeable. Sales of minimally processed foods appear to have increased much less rapidly in exposed than in matched unexposed countries. For processed culinary ingredients, ultra-processed products, and baby food, growth rates appear to be slightly greater in exposed countries, particularly during the post-exposure period, after all exposed countries' U.S. FTAs had entered into force.

Figure 4.2 displays average ratios of sales of fresh versus processed meat and seafood and fruits and vegetables, in exposed, all unexposed, and matched unexposed countries, between 2002 and 2016. At baseline, these values indicate a greater proportion

of fresh sales for both categories in exposed than in matched unexposed countries, suggesting these groups may not be particularly well-matched for comparison of these two outcomes; however, it is evident that matching substantially improved this comparability. Values of both ratios are much larger than one – indicating fresh sales volumes far exceed processed sales volumes – but in both exposure groups these ratios are declining, indicating consumers are purchasing larger proportions of these products in processed varieties. A more rapid decline in both ratios is observed in exposed countries during the exposure and post-exposure periods.

Figure 4.1. Annual mean per capita sales volumes (unadjusted for covariates) in exposed countries, all unexposed countries, and matched unexposed countries (weighted), 2002 to 2016: a) minimally processed foods, b) processed culinary ingredients, c) ultra-processed products, and d) baby foods.
Range of years of entry into force of U.S. FTAs indicated. Units of the y-axes are kilograms per capita (population under age five for baby food and total population for all other outcomes). *(Data from Hong Kong excluded for baby food).*

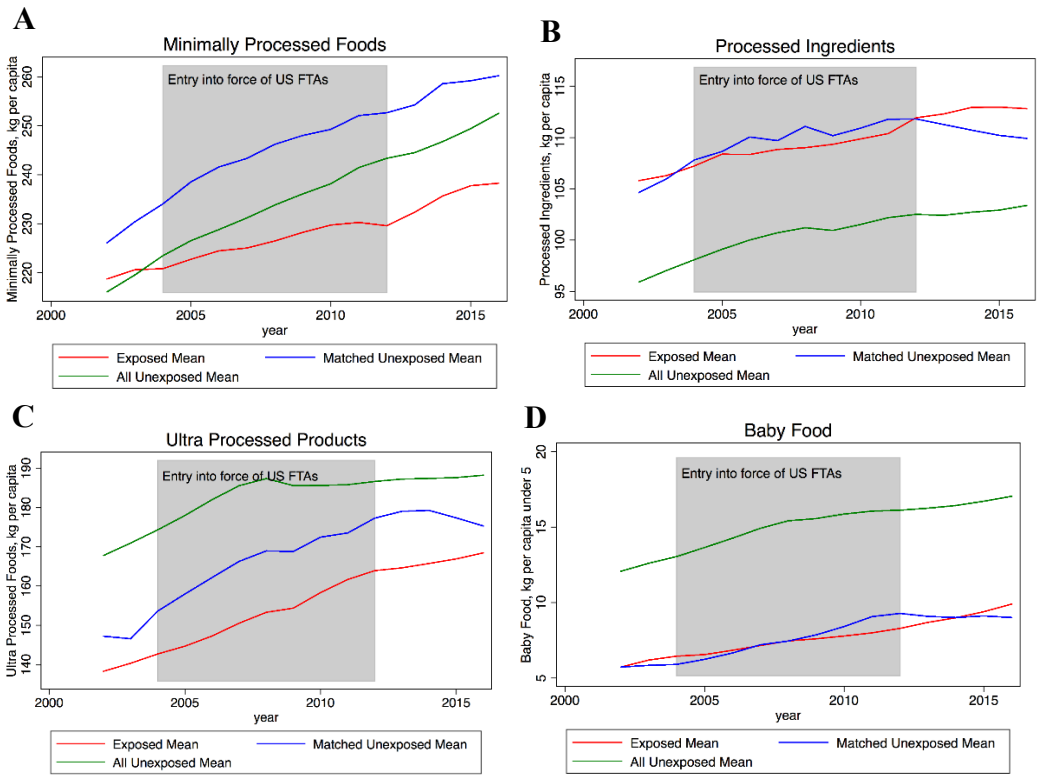
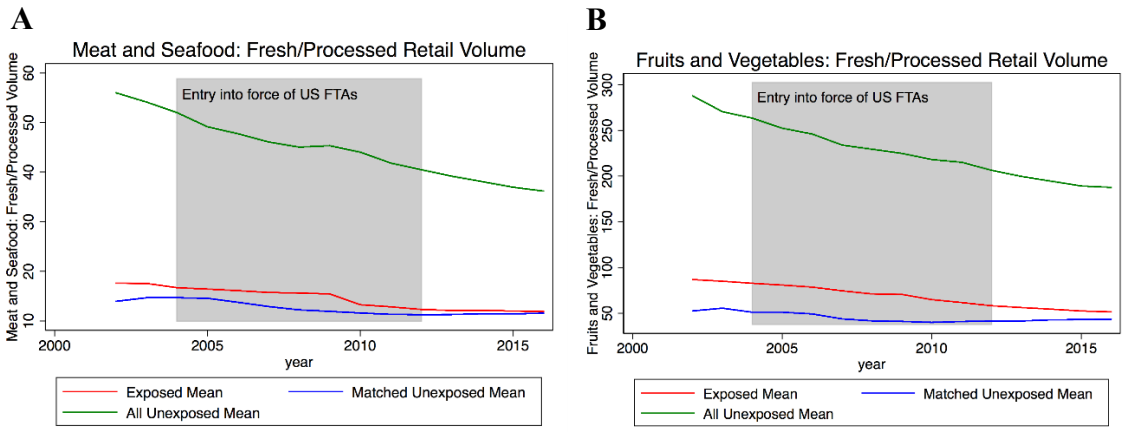


Figure 4.2. Annual mean ratios of fresh versus processed sales (unadjusted for covariates) in exposed countries, all unexposed countries, and matched unexposed countries (weighted), 2002 to 2016: a) meat and seafood and b) fruits and vegetables.
Range of years of entry into force of U.S. FTAs indicated. Units of the y-axes are sales ratios, by weight.



The model output in Table 4.5 provides support for the impacts suggested by the graphs in Figures 4.1 and 4.2. In these models, the magnitude and significance of the coefficients on the treatment and treatment*year terms indicate any difference in the level and trend, respectively, in each outcome after entry into force of U.S. FTAs in exposed versus unexposed countries. Estimated trend changes (treatment*year coefficients) support the study hypotheses, although estimated intercept shifts (treatment coefficients) are more inconsistent and most are not statistically significant. The largest treatment effect is seen for the sales trend of ultra-processed products, estimated to increase by 1.4 (95% CI: 0.62 – 2.2) kg per capita per year. Sales of processed culinary ingredients are estimated to increase by 0.86 (95% CI: 0.53 – 1.2) kg per capita per year and baby food sales are estimated to increase by 0.19 (95% CI: 0.07 – 0.31) kg per capita under age five per year. A declining trend (-0.23 (95% CI: -0.43 – -.04) per year) is estimated for the ratio of sales of fresh versus processed meat and seafood; a much larger decline is

estimated for the comparable fruit and vegetable outcome (-1.7 (95% CI: -2.5 – -0.84) per year). Lastly, no significant change is estimated for sales of minimally processed foods.

Table 4.5. Model output from best-performing model for each outcome.
Coefficients and p-values (in parentheses) presented for fixed effects; variances and standard errors presented for random effects.

Variable	Minimally processed foods	Processed culinary ingredients	Ultra-processed products	Baby Food	Fresh/ Processed Meat & Seafood	Fresh/ Processed Fruits & Vegetables
Treatment	-1.226 *(.218)*	-0.661 *(.157)*	-2.462* *(.029)*	-0.265 *(.150)*	0.674* *(.035)*	3.484** *(.004)*
Treatment*year	-0.104 *(.764)*	0.864*** *(<.001)*	1.396*** *(<.001)*	0.191** *(.002)*	-0.234* *(.019)*	-1.682*** *(<.001)*
GDPpc (log) (2005 Int $)	1.050 *(.858)*	29.63*** *(<.001)*	120.2*** *(<.001)*	6.531*** *(<.001)*	-6.118*** *(<.001)*	-13.34 *(.055)*
Urbanization rate (%)	1.909*** *(<.001)*	-0.359 *(.131)*	-1.761*** *(<.001)*	-0.072* *(.015)*	0.226* *(.010)*	-0.916* *(.050)*
FLFP rate (%)	-0.0562 *(.756)*	-0.111 *(.201)*	1.16*** *(<.001)*	0.005 *(.848)*	0.102* *(.049)*	-0.731*** *(.001)*
Year fixed effects?^	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	70.09 *(.190)*	-134.3*** *(<.001)*	-883.2*** *(<.001)*	-49.06*** *(<.001)*	49.83*** *(<.001)*	297.3*** *(<.001)*
Random effects						
var(intercept) **SE**	3,008 703	1,088 249	6,126 1,456	4.81 1.21	130.4 31.1	5,564 1301
var(slope) **SE**	4.91 1.20	0.95 0.22	4.36 1.04	0.09 0.02	0.37 0.09	14.0 3.16
cov(int., slope) **SE**	67.3 22.2	-1.54 5.26	29.5 26.8	0.19 0.12	-5.94 1.54	-239 59.6
var(residual) **SE**	18.1 1.13	3.96 0.25	23.2 1.45	0.65 0.04	1.91 0.12	26.9 1.68

*p<=0.05; **p<=0.01; ***p<=0.001
^Coefficient values for individual year fixed effects not shown; complete model output available in Appendix F.

Across all outcomes except minimally processed foods (showing no significant change), the coefficient on GDP per capita is large in magnitude, statistically significant, and in the direction expected. For urbanization, coefficients are not large in magnitude overall and are mixed in terms of their expected direction; coefficients on FLFP rate are also not large, but more in line with the expected direction of these relationships. However, interpretation of the control variable coefficients is complicated by matching:

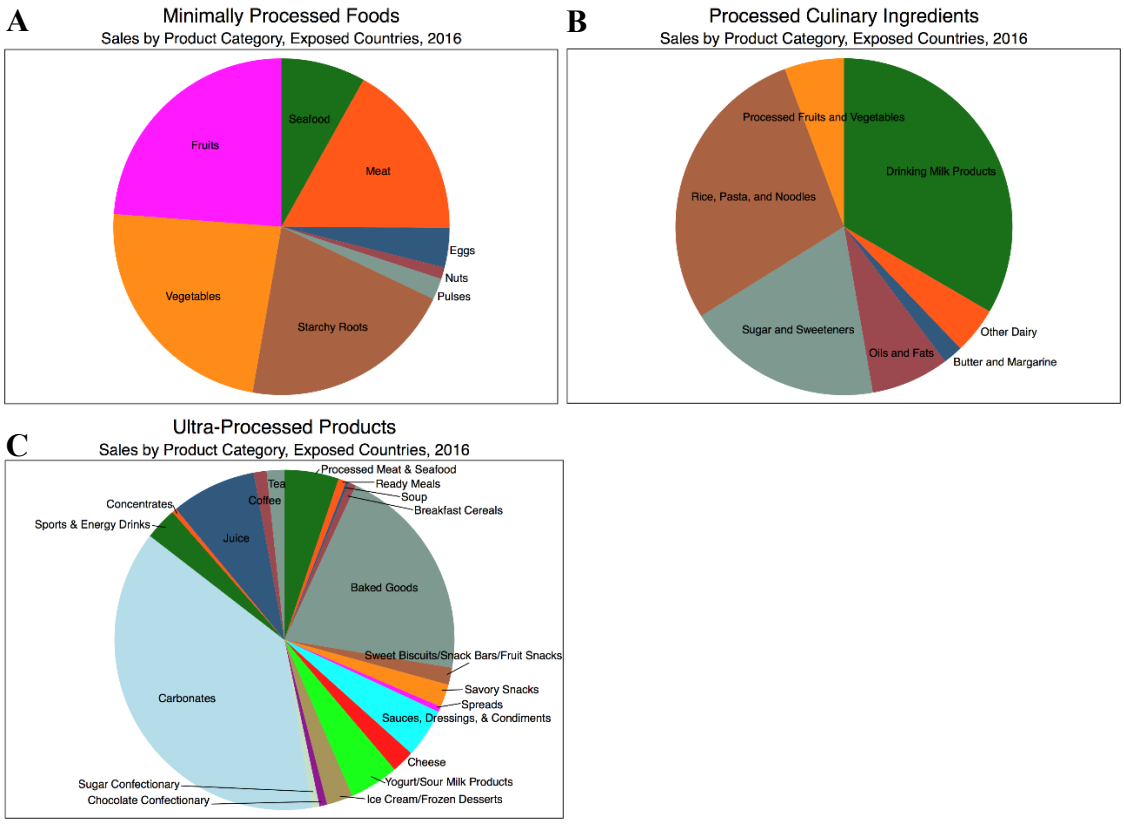
because country income level was used as a match variable, GDP per capita coefficients are not entirely meaningful. Likewise, urbanization and FLFP rate are related to the match variables and therefore, are also not easily interpretable. The variance of the random intercepts indicates there is substantial remaining variation across countries that is not captured by other variables in the models.

In alternative model specifications with the five trade and investment agreement membership covariates, coefficients on these variables were highly inconsistent across outcomes. In these models, estimated treatment effects were generally slightly smaller in magnitude, but generally consistent with the main findings. Results from the various sensitivity analyses also supported the key conclusions. When the ultra-processed products model was run without products that had high missingness (ready-to-drink coffee and tea), results did not substantially change. Likewise, in models excluding Venezuela from the unexposed group, the magnitude of treatment effects changed only slightly for all outcomes. Lastly, when countries with any modelled data were excluded, there were no substantial changes to effects on minimally processed foods nor the two sales ratio outcomes (modelled data primarily only applied to items in these three outcome categories). Key model output from all sensitivity analyses is provided in Appendix F.

To investigate the individual products driving trends in retail volumes in countries with U.S. FTAs, figure 4.3 presents the composition of products in each of the three degree-of-processing categories for exposed countries in 2016. In figure 4.3a, it is evident that minimally processed food sales are driven by fruits, vegetables, starchy roots, meat, and seafood. Sales of processed culinary ingredients, shown in figure 4.3b, are

predominantly comprised of drinking milk products; rice, pasta, and noodles; and sugar and sweeteners. Finally, as seen in figure 4.3c, the products contributing to the majority of ultra-processed product sales are carbonates and baked goods.

Figure 4.3. Composition of total sales, by weight of product group, in exposed group countries in 2016: a) minimally processed foods, b) processed culinary ingredients, and c) ultra-processed products.



Discussion

This analysis is the first to examine the impacts of joining a U.S. FTA on sales of several categories of processed foods in a group countries over time. The direction and magnitude of estimated changes following entry into a U.S. FTA support a consistent understanding of the way food environments change: sales of ultra-processed products, processed culinary ingredients, and baby food increase annually, while no significant

change occurs in sales of minimally processed foods. Thus, effects are only observed for those categories largely comprised of products manufactured, marketed, and sold by TFBCs. This is further supported by estimated declining trends in ratios of fresh versus processed meat and seafood and fruits and vegetables after entry into a U.S. FTA, indicating an increasing proportion of these products are purchased in packaged and prepared varieties.

These results generally confirm findings from earlier research. A previous study identifying a cross-sectional relationship between higher SSB sales and membership in a U.S. FTA (26) is supported by this longitudinal analysis showing an increase in ultra-processed product sales after entry into a U.S. FTA. This analysis also supports trade and investment liberalization as one likely causal mechanism underlying descriptive research showing increases in baby food sales (164) and processed food consumption (180), globally.

These findings are fairly robust to model specifications including covariates for membership in other trade and investment agreements, which control for other liberalizing events. However, estimated coefficients on these variables were highly variable across outcomes, suggesting consistent relationships were not being detected. Thus, results from models without these additional covariates are presented as the main findings of this study. Future research should explore the role of these other trade and investment agreements, as well as the relative importance of different agreements and partner countries, in shaping processed food sales.

Across all outcome models, estimated changes in the intercept and slope after entry into a U.S. FTA were often contradictory, i.e., one was positive and the other was

negative. This may reflect variation across countries in the speed at which the impacts of trade liberalization take effect – plausible given the variation in the mix of retail outlets, extent and quality of distribution systems, and other likely contributing factors across countries. Due to this range of existing conditions, immediate effects may be difficult to generalize (explaining less significant intercept shifts), but may stabilize over time (as detected by the more conclusive trend effects). The large variation in country-specific random intercepts also supports the conclusion that additional unmeasured factors impact sales of these products. Furthermore, variation in country-specific random slopes suggests countries' consumption patterns do not respond uniformly to a U.S. FTA; policies and other factors that may contribute to healthier dietary patterns following liberalization should be investigated and implemented elsewhere to mitigate negative impacts.

Overall, the findings of this analysis have worrying implications for public health. Results indicate that following entry into force of a free trade agreement with the U.S., countries experience steady increases in sales of ultra-processed products, processed culinary ingredients, and baby food. As illustrated in figure 3, nutrient-poor products comprise the majority of ultra-processed product and processed culinary ingredient sales in these ten U.S. FTA partner countries. The largest product groups in these two categories are carbonates (which include SSBs); baked goods; drinking milk products; rice, pasta, and noodles; and sugar and sweeteners.

These findings indicate the importance of ensuring protections for health are included in trade and investment agreements, to mitigate associated declines in the nutritional quality of diets. One possible mechanism to do so is through exemptions to

selected commitments for products that have negative impacts on public health, to ensure governments have the flexibility to enact policies discouraging their sale and consumption (181)(71). Another option is to conduct health impact assessments during the negotiation phase of new agreements, which can identify potential risks to health posed by various provisions and inform ways to mitigate such negative effect (182).

The health impacts of increasing baby food consumption are less clear: baby food is nutritionally inferior to breastmilk but may be superior to other substitute foods that are not specifically designed for infants. Thus, better understanding of patterns of increasing baby food consumption is needed. Likewise, a greater transition from fresh to processed meat, seafood, fruits, and vegetables may have both positive and negative health impacts. Possible positive effects include greater distribution of a wider range of products due to extended shelf lives, thereby increasing dietary diversity, and improved food safety from better preservation techniques. However, processed meat consumption has been causally linked to heart disease, diabetes, cancer, and all-cause mortality (183)(184). Processed and fresh fruits and vegetables are generally considered to be nutritionally equivalent, but processed varieties may be higher in sodium or sugar and there are concerns about possible health risks of chemical additives (185). There may also be more indirect negative health effects from the environmental impacts of additional packaging waste due to replacing fresh with processed products.

Limitations

An important limitation of this analysis is the construction of the outcomes, which was limited by the specificity of the available dataset. This was most problematic for processed fruits and vegetables, which could not be disaggregated and did not completely

align with one outcome category. Processed fruits and vegetables contain items that are both minimally processed (e.g., frozen vegetables) and ultra-processed (e.g., fruits canned in syrup), and were classified as processed culinary ingredients as a compromise. In the future, it would be useful to examine changes in product sales using Poti, et al.'s refined processed food classification system, which includes more specific subcategories for the nature and extent of processing, but requires more detailed data, such as from household food diaries (160). Another limitation of the data used in this analysis is that sales are only a proxy for consumption, which is the true measure that is critical for health. Differences between sales and consumption, due to waste, may be most significant for perishable items.

A fundamental untestable assumption of the CITS analytical approach is that, in the absence of the exposure, outcome trends in the exposed group would resemble those in the unexposed group. We used matching and controlled for known confounders to improve the validity of this assumption, but there may be other extraneous events in exposed or unexposed countries that explain observed differences between the two groups. Even after matching, pre-exposure balance in the outcomes was poor for minimally processed foods and the sales ratios of fresh versus processed meat and seafood and fruits and vegetables, limiting confidence in these results. However, examining multiple countries as opposed to a single exposed-unexposed pair reduces the likelihood that random external factors explain group differences.

Finally, the estimated treatment effects may actually underestimate the impacts of joining a U.S. FTA for two reasons. First, many of the unexposed countries had a U.S. BIT at baseline (not included as a confounder in final model specifications). This was the

variable with the greatest discrepancy between the exposed and matched unexposed countries at baseline (n=1 and n=4, respectively). As a result, unexposed countries' food and beverage markets may be more saturated with U.S. TFBC products than those of countries without U.S. BITs, thereby attenuating observable differences from exposed countries. Second, some of the impacts of a U.S. FTA may be mediated through increasing household incomes, and to a lesser extent through greater urbanization and women entering the labor force (59). Including each of these as control variables in the models may capture some of these indirect effects, thereby diminishing the estimated direct treatment effects attributed to joining a U.S. FTA.

Conclusion

This analysis contributes new longitudinal evidence demonstrating that after joining a U.S. FTA, countries have increased sales of a range of processed foods and beverages, and confirms previous research finding a cross-sectional relationship of higher sugar-sweetened beverage sales among U.S. FTA partner countries (26). Using a natural experiment study design, strengthened with matching to improve the comparability of exposed and unexposed groups, we find that in the years following entry into force of a U.S. FTA, countries experience food purchasing trends with generally negative health implications, although some purchasing changes have possible beneficial implications that require further understanding. Observed changes include: average increases in sales of ultra-processed products of 1.4 kg per capita per year, average increases in sales of processed culinary ingredients of 0.86 kg per capita per year, average increases in sales of baby food of 0.19 kg per capita under age five per year, and a greater proportion of meat

and seafood and fruits and vegetables sold in processed versus fresh varieties. These dietary changes have the potential to increase rates of obesity and several diet-related NCDs in U.S. FTA partner countries. Additional exploration of any country-specific factors mitigating these negative impacts is warranted in order to develop effective policy responses and design provisions to protect health in future trade and investment agreements.

Chapter 5: Analyzing the impacts of global trade and investment on non-communicable diseases and risk factors: a critical review of methodological approaches used in quantitative analyses (Aim 3)

Abstract

Relatively few studies to date have used quantitative methods to investigate the impacts of global trade and investment on non-communicable diseases and risk factors. Recent reviews of this literature have found heterogeneity in results and a range of quality across studies, which may be in part attributable to a lack of conceptual clarity and methodological inconsistencies. This study is a critical review of methodological approaches used in the quantitative literature on global trade and investment and diet, tobacco, alcohol, and related health outcomes, with the objective of developing recommendations and providing resources to guide future robust, policy relevant research. A review of reviews, expert review, and reference tracing are employed to identify relevant studies, which are evaluated using a novel quality assessment tool designed for this study. Eight review articles and 34 quantitative studies are identified for inclusion. Important ways to improve this literature are identified and discussed: clearly defining exposures of interest and not conflating trade and investment; exploring mechanisms of broader relationships; increasing the use of individual-level data; ensuring consensus and consistency in key confounding variables; utilizing more sector-specific versus economy-wide trade and investment indicators; testing and adequately adjusting for autocorrelation and endogeneity when using longitudinal data; and presenting results

from alternative statistical models and sensitivity analyses. To guide the development of future analyses, international data sources for selected trade and investment indicators are presented and key gaps in the literature are identified.

Acknowledgments

Thank you to Ashley Schram and Philip Baker for reviewing the list of quantitative studies.

Introduction

When the United Nations adopted the Sustainable Development Goals as its guiding principles for global development through 2030, this included goal 17, to "revitalize the global partnership for sustainable development" (186). The specific targets comprising this goal identify the need for policy coherence to ensure global macroeconomic stability and sustainable development. One vital area for improved policy coherence is between the public health and international trade and investment sectors. Existing research establishes important links between these sectors (48)(52)(67); however, additional evidence is needed to inform stronger trade and investment policies based on better understanding of their health implications.

Global trade and investment can affect health both positively and negatively in a variety of ways, including through social determinants of health such as poverty and inequality (187)(45), by altering working conditions and exposure to occupational risks (188), contributing to environmental pollution (189), and affecting the price and availability of health services and essential medicines (190)(95). One subject area within this broader literature is the impact of global trade and investment on tobacco, alcohol, and dietary consumption, and resulting effects on non-communicable diseases (NCDs) (85). Facilitating investment and trade in tobacco, alcohol, and nutrient-poor food and beverages can undermine individual- and community-scale interventions intended to reduce consumption of these products. Thus, trade and investment policies must be considered as points of intervention for combatting the growing global NCD epidemic and it is critical to examine the ways in which these policies shape consumption patterns and related health outcomes.

Both quantitative and qualitative research are critical to understanding these dynamics, but quantitative research in this area faces particular challenges that are the focus of this review. An article published over 20 years ago considered methodological challenges in assessing the health impacts of structural adjustment programs (SAPs) – sets of policy reforms required as conditions for loans to low-income countries, which typically included measures to liberalize trade and investment (191). Fundamental challenges highlighted in that article continue to complicate research on global trade and investment and health. This includes the difficulty of attributing causality when the counterfactual is unknown and the cause and effect are distally related, and shortcomings of available data, particularly, the difficulty of capturing the aspect of trade or investment of interest with existing indicators. In this review, the approaches taken by studies to address these and other key methodological challenges are identified and evaluated.

To date, a relatively small but growing number of studies have used quantitative methods to investigate the impacts of global trade and investment on tobacco and alcohol use, diet, and related health outcomes. Several recently published reviews present early syntheses of this literature, finding heterogeneity in results and a range of quality across studies. Conflicting findings may be in part attributable to a lack of conceptual clarity on these relationships and methodological inconsistencies (99)(98), warranting further examination of the theoretical underpinnings and analytical methods used in this body of research. Such an assessment can help to resolve inconsistent results and develop recommendations for future quantitative research on these topics that is more robust, consistent, and policy relevant.

The objective of this study is to critically review the quantitative literature on global trade and investment and diet, tobacco, alcohol, and related health outcomes and develop recommendations and provide resources to guide future policy relevant research. This study fills a significant gap in knowledge regarding the strengths and weaknesses of various approaches to measuring trade and investment and examining relationships with NCD-related health outcomes and risk factors, including identifying recommended data sources and indicators for different types of research questions.

Methods

Study design

This study is a critical review, which is distinguished from other types of literature reviews by an aim to go "beyond mere description of identified articles and includ[e] a degree of analysis and conceptual innovation," leading to a "starting point for further evaluation" (97). To this end, the focus of this review is on strengths and weaknesses of this body of literature as a whole, as opposed to strengths and weaknesses of individual studies. The following research questions guided this analysis. In studies examining the impacts of global trade and investment on diet, tobacco, alcohol, and related health outcomes, to date:

1. What study designs have been used?
2. What data sources have been used?
3. What indicators of trade and investment have been used?
4. What health outcome and risk factor indicators have been used?
5. What confounding, mediating, and moderating variables have been examined?

6. What are the strengths of the data and methods used?
7. What are the limitations of the data and methods used?
8. What lessons can be drawn from the existing literature, to inform future policy relevant research?

The methodological approach to identify existing literature was a review of reviews, which provided both an efficient means to identify relevant articles and an opportunity to focus exclusively on methods – as opposed to the consistency of findings, typically the focus of reviews and accomplished by these existing studies. Rather than duplicate the search processes of recent reviews on closely related topics, a review of reviews was particularly well-suited for this study. These recent reviews presented results, but did not attempt to analyze in detail the different methodological approaches taken, providing a starting point for this analysis.

Literature search

To identify review articles on relevant topics, we systematically searched the following databases encompassing multidisciplinary peer-reviewed and grey literature in health, economics, and social sciences: PubMed, EMBASE, EconLit, Scopus, CAB Direct, Web of Science, Cochrane Library, PAIS Index, ProQuest Dissertations and Theses. The following search terms were used to identify matches in the title field: (review OR systematic OR synthesis) AND (trade OR investment OR liberalization OR liberalisation OR WTO OR RTA OR RTAs OR PTA OR PTAs OR globalization OR globalisation OR deregulation OR macroeconomic OR "structural adjustment" OR SAP) AND (health OR disease OR diseases OR NCD OR NCDs OR mortality OR "life expectancy" OR diet OR dietary OR nutrition OR nutritional OR tobacco OR smoking

OR alcohol OR "risk factor" OR BMI OR obesity OR weight). We searched all article types, including reports, conference presentations, and graduate work; results were limited to those available in English and published in 2000 or later. This was decided as a sufficient start date to capture relevant reviews, due to the relatively recent increase in studies published on these topics.

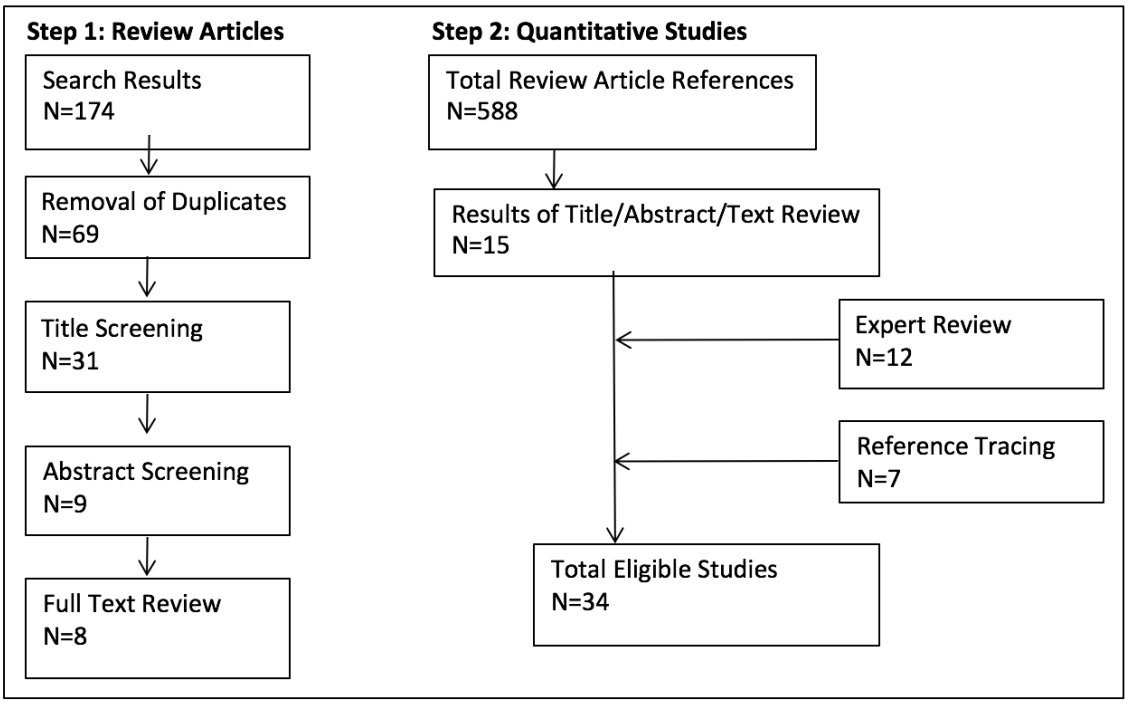
This search yielded 174 total results, of which 69 were unique. After an initial screening of titles for relevance, 31 items were kept for abstract review, resulting in nine items for full text review; six review articles met our inclusion criteria (Figure 5.1). The inclusion criteria for review articles were as follows: 1) self-described as one of the following: systematic review, literature review, synthesis of literature, or qualitative literature review, 2) the inclusion criteria used in the review captured studies examining the impacts of trade or investment, or broader related topics (e.g., globalization, macroeconomic reforms), on one or more of: diet or nutrition; tobacco use; alcohol use; or related health outcomes. These reviews were not limited to quantitative literature, although we only extracted quantitative studies from the reviews. Two review articles (51)(99) contained a reference to another relevant review (192)(88), for a final sample of eight reviews.

We identified quantitative studies captured by each review from lists of included studies in manuscripts or appendices, if provided. We requested these results from review authors not providing such lists in published materials (n=4); however, none provided these and two directed us to the reference lists, so we screened the citations of all review articles instead. From the eight reviews, there were a total of 588 references, although there was substantial duplication in references across studies. Title screening, abstract

review, and full text review were used, as needed, to identify studies matching our inclusion criteria: 15 eligible studies were identified through this process. Additional studies were identified from expert review of this list (including two external experts) (n=12) and from reference tracing from eligible studies (n=7). A total of 34 quantitative studies were included.

The inclusion criteria for quantitative studies were as follows: 1) use of quantitative analysis, which included a statistical test or model and was not purely descriptive, 2) examination of international trade or investment, or a broader related topic (e.g., globalization) as the exposure of interest, 3) examination of one or more of the following outcomes: tobacco, alcohol, or dietary consumption, or related health outcomes (either morbidity or mortality). All studies examining adult mortality or life expectancy were included as these are definitively impacted by diet, tobacco, and alcohol use. Studies examining only infant or child mortality were excluded as out of the scope of this study. Articles were restricted to those available in English; all article types were included and no restrictions were placed on the year of publication.

Figure 5.1. Results of literature search and screening process.



Quality assessment

Three of the eight review articles assessed the quality of identified studies. Key conclusions from those reviews' determinations of quality are presented here and were used as a starting point to develop a new quality assessment tool for use in this study (provided in Appendix G). Existing quality frameworks were considered for this research, but none were sufficiently tailored to research on these specific topics. One review with a similar scope also determined that existing quality assessment tools were not adequately suited to this literature and elected to develop a new tool for this purpose (98). The tool developed for that study assessed traditional measures of quality including the reliability of data, strength of analysis, and presentation of results, providing substantial detail but a more generic assessment. For this study, we opted to develop a simpler and more focused quality assessment tool to provide an evaluation tailored to

applied research in this area – many of the components are uniquely relevant to studies on the topics reviewed here.

The development of this quality assessment tool was heavily informed by the findings and conclusions of the eight review articles. This was designed to specifically assess common weaknesses identified by previous reviews and evaluate the conceptual basis for and appropriateness and consistency of data sources and indicators for different research questions. This encompasses: whether trade and investment indicators align with the aspect of trade or investment being investigated, the specificity of explanatory variables, the choice of confounding variables considered, and the relevance of data sources utilized. In addition, this tool incorporates selected traditional components of study quality, including control for confounding and inclusion of sensitivity analyses. This quality assessment tool was applied to each of the 34 quantitative studies meeting our inclusion criteria. Selected results from the quality assessment were summed across studies, other qualitative trends were identified; these results and conclusions are presented below.

Results

Review articles

Table 5.1 displays key characteristics of the eight review articles; all searched multiple peer-reviewed databases and all but one (McNamara) also searched sources of grey literature. These reviews differed in the degree of specificity to the research questions guiding this review. Some were broader, e.g., encompassed theoretical and qualitative research, and some were more specific, e.g., focused on a particular world

region. As a result, not all identified a large number of quantitative studies relevant to this review, but all provided insights into aspects of the existing literature that can inform future research. Across the reviews, several themes emerged regarding weaknesses of methods used in studies to date and areas for development.

One important area of consensus was the conclusion that many studies do not clearly define the aspect of trade or investment being investigated and that explanatory indicators are often not sufficiently specific. McNamara observes, "authors using trade flows as a proxy for trade liberalization confuse the processes of trade liberalization with its presumed outcomes" and argues for the need for consensus on the concept of trade liberalization in order to develop common measures for future research (51). Barlow et al. also note that studies with stronger methodological designs more commonly used trade indicators with weak specificity (99). Emphasizing the challenges posed by inconsistent definitions and indicators, both reviews focused on quantitative studies (99)(98) were unable to conduct meta-analyses due to the heterogeneity "in measurement methods, research designs, and outcome variables" (99). Friel et al. note a specific absence of existing indicators for monitoring the impacts of trade agreements on food systems and propose several indicators for this purpose (88).

A second theme was the lack of exploration of mechanisms linking trade and investment with risk factors and health outcomes. In particular, Baker, et al. note that understanding of the mechanisms by which transnational food corporations facilitate increased consumption of risk commodities "appear[s] to be theoretically and empirically underdeveloped in the public health literature" (86). Burns, et al. suggest that more stratification should be used in global panel analyses to identify differences based on

factors such as the nature of goods imported and exported, the industries receiving international investments, and countries' positions in global supply chains (98).

A third area of consensus was the need to increase the use of individual-level data and assess impacts by individual-level characteristics. One review concluded that individual-level data has been used surprisingly infrequently for these research questions to date (98). Barlow, et al. note that the strong reliance on country-level data precludes exploration of social groups where effects are concentrated (99). Loewenson highlights the particular importance of understanding the gender dimensions of globalization's impacts (193).

Table 5.1. Review articles: characteristics and key conclusions.

Author (Year)	**Scope/inclusion criteria *(search date range)***	**Number of studies identified***	**Relevant conclusions regarding existing literature**
Breman & Shelton (2007)	Structural adjustment programs (SAPs) and health outcomes, with an emphasis on empirical analyses *(not specified)*	76	- Three main policies of SAPs have been the focus of this literature: reduced government expenditures, liberalized markets, and exchange rate devaluation - "Overwhelming majority" of studies portray the impacts of SAPs on health as negative, but among strictly empirical studies, approximately even split between findings of positive, negative, and neutral impacts
Young, et al. (2009)	Globalization and co-morbidity between infectious and chronic disease: TB & diabetes, HIV & metabolic syndrome *(1950 – end date not specified)*	Not specified	- This review technically met our inclusion criteria but the globalization aspect was very minor in the results/discussion
Loewenson, et al. (2010)	Globalization and nutritional outcomes in sub-Saharan Africa *(1990 – 2009)*	199	- Limited empirical work in Africa - Need for more research on gender dimensions of globalization and health
Friel, et al. (2013)	Studies that developed approaches, methods, or indicators to monitor impacts of trade agreements on food environments from an obesity/NCD perspective; examined	9	- "No studies were identified which used methods or indicators to systematically monitor trade agreements through an obesity/NCD lens" - Proposes potential indicators and food categories for monitoring the impacts of

	impacts of trade agreements on food chains and at least one indicator of the food environment; or conceptualized links between trade liberalization, food chains, and food environments from an obesity/NCD perspective *(1990 – January 2013)*		trade agreements on national food systems and food environments
Baker, et al. (2014)	Trade liberalization, non-communicable diseases, and risk factors in Asia *(not specified)*	Not specified	- Understanding of the mechanisms linking transnational corporations and increased consumption of tobacco, alcohol, and unhealthy foods and beverages "appear to be theoretically and empirically underdeveloped in the public health literature"
Burns, et al. (2016)	Quantitative studies investigating the relationship between international trade or foreign direct investment, and non-nutritional population health outcomes *(until end of 2014)*	16	- Current evidence on FDI as determinant and consequence of health is unclear; more research needed - Sample stratification may critically affect the estimated relationship between trade and health in international panel studies (e.g., nature of goods imported/exported, industry of international investments, position in global supply chain) - Important to consider mutual association when analyzing trade or FDI and health; adjustments for reverse causality were "typically crude" or absent - Surprisingly limited use of individual-level data
Barlow, et al. (2017)	Quantitative studies of the health impacts of trade and investment agreements or policy *(1960 – January 2016)*	17	- "Trade and investment measures varied in specificity" - Studies with stronger methodological designs most often used trade indicators with weak specificity - Mechanisms mediating links were seldom explored - Strong reliance on country-level data precludes exploration of social groups where effects are concentrated
McNamara (2017)	Studies explicating a clear analytical framework for conceptualizing pathways between trade liberalization and health *(until end of 2015)*	43	- "Many authors include financial flows and foreign investment within conceptualizations of trade liberalization" - "Trade liberalization itself is seldom explicitly defined in frameworks"

**Number of studies specified by the authors as meeting the inclusion criteria of the review, not the number of references.*

Quantitative studies

Of 34 quantitative studies examining the relationship between global trade or investment and tobacco, alcohol, diet, or related health outcomes, 18 studies examined at least one NCD-related health outcome, either morbidity or mortality. Ten studies examined changes in one or more aspects of dietary intake and nine studies considered average body mass index (BMI) or the prevalence of overweight or obesity. Tobacco and alcohol consumption were assessed by only three studies and one study, respectively. In ten studies, the stated exposure of interest was globalization; seven studies used a broad similar exposure such as "market deregulation" or "economic freedom"; 15 studies had a primary focus on some aspect of trade; and five studies examined investment, although how each of these was conceptualized and quantified was highly variable and inconsistent across studies. (These numbers sum to more than 34 because several studies used multiple exposures and/or outcomes).

The vast majority of studies (*n*=29) examined associations over time using longitudinal data; only five studies used strictly cross-sectional data with outcomes observed at a single point in time. Most studies examined a large number of countries (mean sample size was 64 countries) over one or more decades (on average, data spanned 23 years, ranging from 1960 to 2014). Three studies used natural experiment designs (62)(63), with one employing synthetic controls (64). Nearly all studies reported using fixed effects regression models; exploration of random effects was infrequently reported (*n*=4) (69)(70)(194)(195). Two studies used path analysis (196), one with structural equation modelling (59). Five studies used instrumental variables (66)(60)(197)(198),

one with a gravity model (199). Tables 5.2, 5.3, and 5.4 display selected characteristics of these 34 studies. Additional details by individual study are provided in Appendix H.

As shown in Table 5.2, the three most frequently used explanatory variables were the KOF Globalization Index (constructed from indicators reflecting economic, social, and political dimensions of globalization) (200); total trade (sum of imports and exports) relative to GDP; and total FDI inflows as a percent of GDP. The World Bank World Development Indicators database was the most commonly cited source of estimates of trade and investment flows. Authors using the KOF Globalization Index, or one of four other multifaceted indices (201)(202)(203)(204), all elected to parse out a subcomponent most relevant to trade and investment. A smaller number of studies used binary indicators to distinguish the time period before and after entry into force of a specific agreement (World Trade Organization (63), North American Free Trade Agreement (64), bilateral U.S. free trade agreement (62), and Section 301 of the U.S. Trade Act (65)) or successful implementation of a structural adjustment program (SAP) (205). Across nearly all studies (n=30), explanatory indicators reflected economy-wide attributes, as opposed to sector-specific indicators more relevant to the outcomes investigated, as used in only four studies (206)(61)(207)(197).

Table 5.2. Trade and investment indicators used in quantitative studies.

Indicator	Number (%) of studies using as explanatory variable
KOF Globalization Index (Swiss Federal Institute of Technology)	9 (*26*)
FDI inflows/GDP *(%)*	8 (*24*)
Total trade (imports + exports)/GDP *(%)*	8 (*24*)
Entry into force of a specific agreement or SAP *(indicator variable)*	5 (*15*)
CSGR Globalisation Index (Univ. of Warwick)	2 (*6*)
Economic Freedom of the World Index (Fraser Institute)	2 (*6*)
Mean applied tariff rate	2 (*6*)
Average imports, weighted by partner countries' infant mortality rates	1 (*3*)
Black market premium	1 (*3*)
Imported food/total food *(%)*	1 (*3*)
Index of Economic Freedom (Heritage Foundation/WSJ)	1 (*3*)
Index of service sector liberalization (World Bank)	1 (*3*)
Maastricht Globalisation Index (Univ. of Maastricht)	1 (*3*)
Sachs-Warner Index *(indicator variable)*	1 (*3*)

Counts and percentages presented do not sum to the total number of studies reviewed (100%) because some studies used multiple explanatory indicators.

Table 5.3 displays the NCD-related health outcome and risk factor indicators used in these quantitative studies. The most frequently used indicators were life expectancy at birth and mean BMI. A wide range of dietary indicators were used across studies; sugar-sweetened beverages (SSBs) have received the greatest focus within this literature. Three studies examined SSB imports or sales (61)(63)(62) and additional studies explored these indirectly through their contribution to consumption of sugars, caloric sweeteners, and ultra-processed products. Tobacco consumption was measured using cigarette consumption or tobacco sales per capita; alcohol consumption was measured using alcohol sales per capita.

Table 5.3. NCD-related health outcome and risk factor indicators used in quantitative studies.

Category	Indicator	Number (%) of studies using as outcome variable
Health outcomes	Life expectancy (total and/or by sex)	14 (*41*)
	Adult mortality rate (probability of death between ages 15 and 60)	3 (*9*)
	CVD mortality rate	1 (*3*)
	Diabetes prevalence	1 (*3*)
	NCD mortality rate	1 (*3*)
	Proportion of deaths attributable to CVD	1 (*3*)
Over-nutrition	Mean BMI (adults, total and/or by sex)	5 (*15*)
	Obesity prevalence (total and/or by sex)	4 (*12*)
	Overweight prevalence (total and/or by sex)	2 (*6*)
Diet	SSB imports/sales per capita	3 (*9*)
	Consumption per capita for selected food groups (e.g., animal proteins, sugars)	2 (*6*)
	Average caloric intake	1 (*3*)
	Consumption of 'unhealthy' foods (% of total spending/caloric intake)	1 (*3*)
	Supply of caloric sweeteners per capita	1 (*3*)
	Ultra-processed products sales per capita	1 (*3*)
Tobacco	Cigarette consumption per capita	2 (*6*)
	Tobacco sales per capita	1 (*3*)
Alcohol	Alcohol sales per capita	1 (*3*)

Counts and percentages presented do not sum to the total number of studies reviewed (100%) because some studies used multiple outcome indicators.

Outcome variables were most often constructed from three key sources of country-level information: World Bank World Development Indicators (WDI), Euromonitor International Global Market Information Database, and the Food and Agriculture Organization (FAO). WDI provides a wide range of social and demographic data, including life expectancy and selected mortality estimates. Euromonitor's database of product-specific retail sales covers several foods and beverages, tobacco, and alcohol. FAO statistics include quantities of production, imports, exports, and supplies of selected commodities, and makes these estimates available in units of derived nutrients (calories, proteins, fats). Only four studies used individual- or household-level data from national health, consumption, or expenditure surveys (207)(208)(209)(70).

In Table 5.4, country-level confounding variables used in two or more studies are presented. Individual- and household-level confounders are excluded due to the small number of studies examining data at these levels; confounders explored in only one study are not listed because many of these were specific to a particular research question and do not have wider applicability. By far, the most frequently used confounder was a measure of economic size (n=26), typically GDP per capita. Other confounding variables included in several analyses were the percent of the population living in an urban area or the urban growth rate (n=10); a measure of population, either total, density, or the growth rate (n=7); an indicator of educational attainment, either average years of school, enrollment rates at one or more levels, or adult literacy (n=6); and income inequality, typically the Gini coefficient (n=4). Seven studies did not include any confounding variables in any model specifications. Most studies used data from the WDI to construct one or more of these indicators.

Few studies used statistical approaches to investigate mediating variables as possible mechanisms of broader relationships. One study examined fast food transactions as a mediator between market deregulation and mean BMI, and in addition, examined total caloric intake, animal fat, and soft drink consumption as mediators between fast food transactions and BMI (60). Two studies explored economic inequality as a mediator for globalization – one for effects on life expectancy (196) and one for impacts on mean BMI (195). One study each examined: FDI inflows as a mediator between joining a U.S. FTA and SSB sales (62); overweight prevalence and tobacco use as mediators between trade and investment policies and CVD mortality (59); and GDP per capita, the measles

immunization rate, and government health expenditures as mediators between trade flows and life expectancy (199).

Table 5.4. Country-level confounding variables controlled for in two or more quantitative studies.

Indicator	Number (%) of studies using as confounding variable
GDP (or GNI) per capita (including squared term or growth rate)	26 (*76*)
Urbanization rate (or urban growth rate)	10 (*29*)
Population (total, density, or growth rate)	7 (*21*)
Educational attainment (years completed, enrollment rate, or literacy rate)	6 (*18*)
Income inequality	4 (*12*)
Female labor force participation rate	3 (*9*)
Health expenditure (% of GDP, total or public)	3 (*9*)
Average caloric intake	2 (*6*)
Consumer price index	2 (*6*)
Dependency ratio	2 (*6*)
FDI (total or % of GDP)	2 (*6*)
Fertility rate	2 (*6*)
Political rights/civil liberties index	2 (*6*)
Polity score	2 (*6*)
Immunization rate (any type)	2 (*6*)
Smoking prevalence	2 (*6*)
No confounders included/tested in models	7 (*21*)

Counts and percentages presented do not sum to the total number of studies reviewed (100%) because most studies controlled for multiple possible confounders.

Among studies using national-level data, the predominant moderating variable explored was country income level – either using GDP per capita or a categorical variable for high-, middle-, and low-income countries. Four studies explicitly included one of these measures as a moderator in regression models (either through stratification or an interaction term) (210)(211)(66)(212). In addition, many studies used a sample of countries of a limited income range (e.g., OECD countries), implicitly exploring relationships which may differ from those in countries at different levels of national wealth. A few additional moderating variables were considered by only one or two studies. One study assessed whether there were differences in the association between economic freedom and BMI among "market liberal" countries (i.e., U.S., U.K., Canada,

and Australia) versus others (194). Another examined world region as a moderator between successful implementation of a SAP and life expectancy (205). Another using BMI, by sex, as the outcome explored gender as a possible moderator of the relationship with globalization (195). A high level of political rights was explored as a possible moderator of the relationship between economic freedom and life expectancy in one study (213). Finally, two studies created categorical versions of either the explanatory or outcome variable to examine differences in the relationship between globalization and overweight or obesity prevalence: one converted globalization index scores to quartiles (208) and one used deciles of obesity rates (69). One study also created categories from outcome variable values (components of the food supply) to examine differences in the relationship between globalization and the food supply (214).

Studies using individual- and household-level data were more likely to examine moderating factors. One study using household-level data explored urban versus rural residence as a moderator of the relationship between the proportion of imported food (at the national level) and consumption of "unhealthy" items (207). Another used the interaction of gender and urban/rural location to explore differences in the relationship between macroeconomic factors and BMI (70). A study on dietary patterns following the opening of South Korea's food industry to the global economy examined differences in consumption by age group and sex (209).

Study quality

Two of the eight reviews also focused exclusively on quantitative studies and included assessments of study quality; these studies reached similar conclusions that the overall quality of this evidence is moderate. Burns et al. found that country-level analyses

were of generally high quality, while individual-level studies were of lower quality overall (98). Barlow et al. deemed six studies to be strong, eight to be moderate, and three to be weak, and concluded that overall, "considerable limitations in existing studies preclude definitive conclusions of causality" (99). Through application of our quality assessment tool to 34 studies, we confirmed these and other major conclusions of previous reviews and identified additional strengths and weaknesses of this literature to date.

Across studies, a key strength was the inclusion of sensitivity analyses. Due to the number of methodological choices required in these analyses, the presentation of sensitivity analyses and alternative model specifications helps to indicate that findings are not spurious and based on a very specific set of design and modeling decisions. Most studies (n=28) reported at least one sensitivity analysis and/or described the robustness of findings to alternative model specifications. However, there was substantial variability in the degree to which studies explored and described these variations. The strongest studies provided multiple model specifications, for example, with and without selected confounding variables, as well as reported the results of sensitivity analyses, such as varying the set of countries included in the sample or altering the construction of outcome variables.

Another key strength, specific to the 13 studies that used a globalization or macroeconomic index as an explanatory variable, was that all authors disaggregated the index to assess a component more specific to trade or investment. For example, from the KOF Globalization Index, many authors examined the economic dimension separately from the social and political dimensions (e.g., (59)); from the Maastricht Globalization

Index, one study separated the economic domain from four other domains (215). For analyses intending to examine trade or investment as the exposure of interest (versus globalization more generally), such disaggregation generates explanatory indicators better aligned with the research questions. This is likewise more informative for readers most interested in the trade and investment aspects of globalization.

A key weakness of these studies was a general lack of clarity about the aspect of trade or investment being explored, often regarding its precise definition as well as its relationship to the indicator used to reflect it. Across studies, the same indicators were used to represent different constructs. Total trade relative to GDP was used as a measure of trade openness (210)(216), trade liberalization (66)(212), and economic globalization (217); FDI was used as a measure of globalization (211) and "market integration" (26). Even within a single study, these terms were sometimes used interchangeably (e.g., trade openness was equated with economic globalization (217)). The various globalization and macroeconomic indices, used in several studies, conflate trade and investment, implicitly suggesting that similar mechanisms link either or both to the outcome(s) and precluding any disentanglement of these effects. Only four studies considered both trade and investment as separate explanatory indicators (62)(69)(70)(216).

One challenge of many longitudinal analyses, relevant to these topics, is the possibility of endogeneity, or reverse causality. Only one of the reviews discussed the need to better account for reverse causation, which the authors noted many studies had not even attempted to address (98). Of 29 quantitative studies using longitudinal data, ten mentioned any use of methods to assess or control for endogeneity through the study design or statistical models. Studies that did so approached this in a variety of ways –

most included lagged independent variables in regression models (e.g., (218)(219)), others used instrumental variables (197)(198) or switched the independent and dependent variables to examine the presence of any measurable relationship in the opposite direction (210).

Another key issue with longitudinal data is the likelihood of autocorrelation between repeated observations for the same country (or individual or household). 13 of 29 studies using longitudinal data described some attempt to adjust for autocorrelation in statistical models, through a variety of different means: robust standard errors, use of lagged dependent variables as predictors, or by imposing correlation structures on model residuals.

Inventory of data sources

As a resource for future research on these topics, an inventory of data sources for measuring trade and investment, identified from these studies, is presented in Table 5.5. These are supplemented with additional data sources known to the authors. Data are organized by the aspect of trade or investment (policy, liberalization, flows) measured by each, to encourage the use of data and indicators appropriately aligned with research questions.

Table 5.5. Trade and investment policies, liberalization, and flows: data sources and example research topics.

Topic	Data	Example types of research topics	International data sources
Policy	Treaty membership	Changes occurring after entry into force of a specific agreement	• WTO membership database • UNCTAD International Investment Agreements Navigator
	Depth of commitments in specific agreements	Differences correlated with the degree of commitments in different agreements	• Design of Trade Agreements (DESTA) project • Mapping BITs

	Presence and outcome of trade or investment disputes	Sales patterns or regulatory activity (or lack thereof) in countries after being party to relevant product disputes	• WTO Dispute Settlement Gateway • UNCTAD Investment Dispute Settlement Navigator
Liberalization	Average tariff rates	Relationships between average tariff rates and imports or sales of product groups	• World Bank World Development Indicators
	Product-specific tariff rates	Relationships between tariff rates for specific products and imports or sales of those products	• UNCTAD TRAINS database • WTO Tariff Download Facility
	Non-tariff measures	Changes in product-specific consumption patterns following implementation or removal of non-tariff measures governing those products	• UNCTAD TRAINS database • USDA Foreign Agricultural Service reports • UNCTAD International Investment Agreements Navigator
Flows	Total FDI	Relationships between FDI inflows and sales of product groups	• World Bank World Development Indicators • IMF international Financial Statistics • UNCTADstat
	FDI, by sector & industry	Trends in sector-specific investments following changes in investment policy	• International Trade Center database • UNCTADstat (by request)
	Total imports and exports	Relationships between import and export volumes and household consumption or expenditure patterns	• World Bank World Development Indicators
	Product-specific imports & exports	Trends in product-specific imports and exports following changes in trade or investment policy	• UN Commodity Trade Statistics (UN Comtrade) • World Bank World Integrated Trade Solution (WITS) • FAO Food and Commodity Balance Sheets • Index Mundi • USDA Foreign Agricultural Service
	Retail sales	Proportion of product-specific sales that are of foreign versus domestic brands following changes in trade or investment policy	• Euromonitor Global Market Information Database
	Retail prices	Changes in product- and brand-specific prices following changes in trade or investment policy	• Euromonitor Global Market Information Database • WHO MPOWER database

Discussion

This study reviewed eight review articles and examined 34 quantitative analyses of global trade and investment and diet, tobacco, alcohol, and related health outcomes. This is the first analysis with a primary focus on the methodological approaches of studies on this topic, providing a point of reflection and practical guidance and resources for this area of research in the future. Several important weaknesses of this literature were identified: exposures are often not well defined; mechanisms have not been sufficiently explored; the choice of confounding variables is highly inconsistent; and autocorrelation and endogeneity are often not accounted for in longitudinal analyses. The inventory of explanatory and outcome variables used across studies, as well as identified gaps in this literature, suggest priorities for future work and offers possible ways to construct these analyses. Citations for studies with different characteristics provide examples of design or analysis features that other researchers may be interested in applying. Lastly, the inventory of data sources identifies where data can be accessed and classifies sources in a way that enables each to be appropriately aligned with indicators and research questions.

Literature search results

A greater than expected proportion of the quantitative studies examined in this review were identified through expert consultation or reference tracing, rather than from the review of reviews. A few possible explanations may in part account for this. First, several quantitative studies were recently published, and may have been outside the dates searched by previous reviews. Second, the scopes of the review articles did not precisely align with the present study, although collectively the inclusion criteria of those studies encompassed the criteria used in this review. Third, this area of research is

interdisciplinary by nature, resulting in literature that is dispersed across disciplines and databases; search methods of previous reviews may not have sufficiently covered this range of sources. As a result of the large number of studies identified outside of existing reviews, another more traditional review on this topic – focused on the magnitude and consistency of measured effects – may be warranted to complement the methodological focus of this study, although existing reviews were unable to conduct meta-analyses due to the heterogeneity in methods used in this literature.

At the review article screening stage, four reviews were excluded because these assessed studies on trade and investment and health services, indicating the prominence of this subtopic within the trade, investment, and health literature. At the quantitative study screening stage, one or more articles were excluded due to a focus on health impacts via: labor conditions, access to medicines, or environmental pollution, reflecting the role of these pathways in linking global trade and investment and NCDs. The vast majority of articles were excluded at this stage due to an absence of any statistical analysis; this literature is predominantly comprised of qualitative analyses and articles presenting strictly descriptive data. While this review did not ascertain the overarching perspective taken on the health impacts of global trade and investment by all types of studies, researchers should be cautious of generating a body of literature dominated by normative and theoretical work that is divorced from the findings of empirical analyses. The conclusion of the review of literature on the health impacts of SAPs provides a warning: the "overwhelming majority" of studies portrayed the health impacts of SAPs as negative, but among strictly empirical studies, there was an approximately even split between findings of positive, negative, and neutral impacts (192).

Gaps in existing research

This analysis revealed important gaps in the literature on NCD-related impacts of global trade and investment. Several important outcomes have been the focus of little to no research to date. Alcohol use has been evaluated by only one study. Furthermore, no studies have used the *prevalence* of tobacco or alcohol use as outcomes (instead only examining sales or consumption). Prevalence is important because the distribution of use can elucidate whether any effects are explained by changes in the volume consumed by current users or by attracting new users. Another area for additional research is childhood obesity, an important determinant of NCDs in adulthood (220) that has not been examined in the context of global trade and investment, to our knowledge. Childhood obesity may be affected by trade-related increases in consumption of infant formula or nutrient-poor food, both suggested by existing studies (164)(221), but not examined in relation to specific impacts on children's health. Finally, few studies have examined morbidity due to specific NCDs or NCD-related mortality, as opposed to the relatively frequent exploration of life expectancy and all-cause mortality.

In terms of explanatory variables, investment has been studied far less than trade. Furthermore, in combining trade and investment in many studies, there seems to be an assumption that it is not critical to distinguish the two, when in fact, these may operate through very different mechanisms. For example, while key effects of liberalized trade may occur through increased imports, the impacts of liberalizing investment may operate through increases in local production, which have different implications. Another area unexplored to date is comparison of effects of different trade and investment agreements based on the depth of commitments involved, which requires quantifying commitments

for statistical analysis. Two sources provide this type of data: the Design of Trade Agreements (DESTA) database (222) (for trade agreements) and Mapping BITs (223) (for investment treaties). A related challenge is the difficulty of quantifying non-tariff measures, for which a range of alternative techniques are available (224).

Several studies, including many that examined life expectancy or adult mortality as outcomes, also explored the impacts of trade, investment, or globalization on child health outcomes. In this subset of the literature, infant and child mortality rates appear to be the most common outcomes, unsurprising as these are among the most widely available indicators across countries and over time. As one approach, greater use of household-level data could aid in assessing more nuanced indicators of child health, including childhood obesity, mentioned above. To our knowledge, no methodological review exists for this group of studies, which may also benefit from a critical review of methods to guide future research and improve understanding of the impacts of global trade and investment on children's health.

Implications for future research

Three areas of consensus across the eight review articles were confirmed by our analysis of methodological strengths and weakness of 34 quantitative studies: the need to clearly define exposures of interest and not conflate trade and investment; the lack of exploration of mechanisms of these relationships through analysis of mediating variables; and the limited use of individual-level data for these research questions. Additional ways to improve the robustness of future studies were also identified: developing consensus and consistency in the choice of key confounding variables; utilizing more sector-specific versus economy-wide trade and investment indicators; testing and adequately adjusting

for autocorrelation and endogeneity when using longitudinal data; and presenting results from alternative statistical models and sensitivity analyses, given the lack of consensus regarding many methodological decisions. The implications of each of these findings for future research is elaborated below.

First, future studies on these topics should explicitly delineate the aspect of trade or investment being explored, i.e., whether a particular *policy*, the degree of *liberalization*, or *flows* of goods or capital is the exposure of interest. Examples of different aspects of these three distinct facets of trade and investment are distinguished in Table 5.5, along with possible data sources for each. As previously noted by McNamara (51), the commonly employed metrics of total imports and exports and total FDI inflows (as percentages of GDP) are measures of trade and investment *flows* – reflecting the impacts of policies or liberalizing actions, as opposed to measuring these attributes themselves. Without agreement on these definitions and the indicators used to reflect each, it will remain difficult to synthesize and compare findings across studies – a challenge that has complicated previous attempts at meta-analysis (98)(99).

Studies using indices as explanatory variables and life expectancy or all-cause mortality as outcomes may be least informative for policy, due to the lack of specificity in both predictors and outcomes and the myriad of possible confounding factors. Each of the indices used in one or more of these studies combines aspects of trade and investment, precluding understanding of their unique impacts. It is arguable whether any additional studies of these types are needed and researchers are encouraged to consider whether more nuanced and specific research questions may produce more actionable information.

Second, there is a need for additional research that explicitly explores mechanisms linking global trade and investment to NCD risk factors and health outcomes. As pointed out by Barlow, et al., dichotomous indicators signifying entry into force of an agreement treat these as "black boxes," providing no understanding of which specific policies account for outcomes (99). The study by DeVogli that examines market deregulation, fast food consumption, soft drink, animal fat, and total caloric intake, and mean BMI, provides a useful example of an investigation of a cascade of events with presumed causal connections. More nuanced explorations of this sort will generate more actionable information for policy decisions.

Third, as also discussed in previous reviews, greater use of individual-level data can facilitate identification of any subpopulations where health impacts of trade and investment are concentrated, critical considering that the economic benefits of trade and investment are known to be unevenly distributed. While often faced with challenges of comparability across countries, greater reliance on household- and individual-level data may also help to fill several of the research gaps discussed above, particularly regarding NCD morbidity and the prevalence of tobacco and alcohol use as outcomes.

Fourth, a broad range of confounding variables were inconsistently used across studies, including many that controlled for factors that were elsewhere used as exposures or outcomes. This suggests the need for research that is firmly grounded in a conceptual model illustrating the mechanisms and factors influencing the hypothesized effects. The degree to which theoretical and empirical research on these topics may be siloed is illustrated by the results of the 2017 review by McNamara, for which the inclusion criteria specified that studies "explicat[e] a clear analytical framework for

conceptualizing pathways between trade liberalization and health" (51). No quantitative studies for this review were identified from studies meeting that review's inclusion criteria – it is significant that studies providing a strong conceptual basis for these links and those including quantitative analysis are so far mutually exclusive.

Fifth, the finding that only six studies to date have used any type of sector-specific, as opposed to economy-wide, indicators, suggests an opportunity for new research that is more nuanced and informative. However, a key challenge to increasing use of sector-specific information is the paucity of data. Mendez, et. al. provide arguably the best analysis of sector-specific data to date, using product-specific applied tariff rates, but acknowledge their analysis would be strengthened with FDI data by sector, which were not available (61).

Finally, principles of study quality that apply to longitudinal analyses more generally are pertinent to this literature. All studies using longitudinal data should examine data for the presence of autocorrelation and adjust for this using one or more statistical approaches to ensure standard errors and significance tests are valid. The possibility of reverse causality in data on these topics should also be considered and researchers should describe how this is assessed or accounted for in the study design or analysis. Given the many methodological choices required, the substantial potential for confounding, and the inconsistency of findings from past research, it is critical to include sensitivity analyses and assess the robustness of findings to model specification to accurately portray the certainty of study conclusions.

Limitations of this review

Important factors may limit the findings and conclusions of this review. First, there may be additional studies meeting the inclusion criteria for either review articles or quantitative studies that were not captured by the selected search strategies. However, we attempted to minimize this possibility by using multiple databases to identify review articles and multiple search methods to identify quantitative studies. Second, publication bias may affect the content of studies available in the literature and as a result, findings and conclusions may not reflect all studies conducted on these topics. Third, all findings and conclusions are based on the lead author's reading of this literature and may be subject to misinterpretation of individual studies or assumptions regarding study methods based on limited information provided in manuscripts. Finally, the quality assessment in this study focused on study design and did not encompass many aspects of statistical analysis, an assessment of which may identify additional strengths and weaknesses of this literature.

Conclusion

The findings and resources in this review provide methodological guidance to inform future policy relevant research, based on a review of eight review articles and an assessment of 34 quantitative studies covering global trade and investment and tobacco, alcohol, diet, and related health outcomes. Future quantitative research on these topics should strive to clearly define exposures of interest and avoid conflating trade and investment; explore mechanisms of these relationships through analysis of mediating variables; and consider expanding the use of individual- and household-level data. Across

this body of work, there is a need for consensus and consistency in the choice of key confounding variables, grounded in conceptual frameworks. Although not widely available for all exposures or outcomes, more sector-specific data should be creatively explored to pose more nuanced research questions. Longitudinal analyses should test and adjust for autocorrelation and endogeneity and all analyses should present results from alternative statistical models and sensitivity analyses.

It is critical to continue to build a body of rigorous quantitative research that measures the impacts of global trade and investment on NCD-related health outcomes and risk factors. Additional research on these topics can help to convince policymakers of: the necessity of prospectively assessing potential health risks when designing new trade and investment agreements, preserving policy space to implement health-promoting policies that may have restrictive effects on trade or investment, and upholding such policies if challenged in trade or investment disputes.

Chapter 6: Discussion

Rationale and objectives

A literature examining possible negative health implications of global trade and investment has emerged over approximately the last 20 years. Prominent issues in this context include the price and availability of medicines (49) and health services (95); health effects from changing environmental and labor conditions (27); legal challenges to tobacco and alcohol control measures (67)(225); and changing dietary patterns due to shifts toward export-oriented agricultural and new food imports (50). These concerns have arisen during a period of rapid liberalization of both trade and investment, globally. Significant events during this time include the establishment of the World Trade Organization (WTO) in 1995, steadily adding new members amounting to a current membership of 164 countries (29); an exponential increase in the number of regional trade agreements, with 297 now in force worldwide (32); and a proliferation of international investment treaties, both stand-alone (2,360 in force), and through other treaties with investment provisions (307 in force) (33).

Global trade and investment have transformed economies and societies – changing livelihoods, norms, and habits. The spread of "Western" lifestyles includes increases in the risk factors and illnesses that are dominant causes of the disease burden in high-income countries – tobacco and alcohol use and consumption of nutrient-poor foods (127). As recognition of unhealthy lifestyle changes has grown, governments seeking to discourage consumption of these high-risk products can encounter limits to available policy options, imposed by the same trade and investment agreements that have

made these products more available (71). The cumulative impacts of the global diffusion of tobacco, alcohol, and poor diets, and the prioritization of trade and investment protections over health, have converged in the form of populations afflicted by an ever-growing number of NCDs, now responsible for the majority of morbidity and mortality worldwide (226).

During this era of substantial growth in the volume and scope of global trade and investment agreements, with their attendant expanded and strengthened international legal protections (227), international authority for ensuring the protection and promotion of health has arguably weakened. The leading public institution overseeing global health, the World Health Organization (WHO), has an inadequate budget and, particularly after the response to the 2014-15 Ebola epidemic, faces questions about its legitimacy and necessity (228). While official development assistance for health has dramatically increased during these years – growing from U.S. $7.2 billion in 1990 to U.S. $36.4 billion in 2015 (229) – these resources have been overwhelmingly directed towards infectious diseases, reproductive health, and health interventions grounded in the individual biomedical model of disease causation. As a result, there is comparatively little funding for, or political power to support, approaches to global health based on the social determinants of health framework (230), which identifies political and macroeconomic factors, such as trade and investment policies, as critical upstream determinants of population health.

In short, public health is in a losing position vis-à-vis trade and investment – in terms of legal authority, financial resources, political power, or even recognition of its importance. The groundbreaking 2001 report of the Commission on Macroeconomics and

Health (231) is widely credited with establishing the vital importance of population health to economic growth. However, the dominant paradigm still conceptualizes causation primarily in the opposite direction: that wealth generates health.

Thus, research has a vital function in establishing the underappreciated role of trade and investment liberalization in generating and sustaining the global NCD epidemic and the necessity of implementing global and national policies to counter these effects. Several types of research are critical to this body of literature: legal analyses that parse out ramifications of specific commitments in new agreements, policy analyses that evaluate the strengths and weakness of different policy options, and case studies that use qualitative or descriptive data to provide in-depth explorations of specific countries or sectors in the wake of liberalizing events. As one piece of this research literature, quantitative analyses can retrospectively evaluate changes in risk factors and health outcomes associated with specific trade and investment policies, documenting and measuring their impacts.

Within the broader literature on the health impacts of global trade and investment, the focus of this dissertation was on quantitative analysis of NCD risk factors. The objectives were to conduct: two empirical analyses of these impacts across countries and over time and a review of the methods used in this literature to date to inform future robust and policy relevant research.

Summary of findings

Aim 1

Using a natural experiment design and comparative interrupted time-series analysis, this study examined trends in consumption of tobacco, alcohol, and seven food groups relevant to the development or prevention of NCDs, between 1980 and 2013, in 21 countries joining the WTO after 1995 and 26 non-member countries. Propensity score weights were used to improve the comparability of the two groups of countries and strengthen the assumption that a causal relationship underlies any observed treatment effects. Results from multivariate random-effects linear models suggest that following accession to the WTO, countries experienced large immediate increases in fruit and vegetable consumption and steady gradual increases in tobacco and alcohol consumption. Statistical models identified no significant impacts on consumption of red meats and animal fats; seafood; nuts, seeds, and legumes; starches; or edible oils. Results for sugar consumption were inconsistent across model variations. Graphical results suggested the presence of additional treatment effects that were not supported by statistical models: dramatic increases in seafood and sugar consumption and a slight increase in red meat and animal fat consumption in countries after WTO accession, compared to weighted unexposed countries. Overall, significant effects were not highly robust to model specification and regression results indicated substantial remaining country-level heterogeneity in impacts.

Aim 2

This study used a natural experiment study design and comparative interrupted time-series analysis to assess changes in sales of processed foods and beverages, between

2002 and 2016, in ten countries joining U.S. free trade agreements (FTAs) and 11 matched countries without U.S. FTAs in force. Results from multivariate random-effects linear models indicated that after countries joined a U.S. FTA, sales of processed culinary ingredients, ultra-processed products, and baby food all increased annually. A slightly declining trend was found for the ratio of sales of fresh versus processed meat and seafood and the ratio of sales of fresh versus processed fruits and vegetables. Finally, no significant change was estimated for sales of minimally processed foods. The direction, magnitude, and significance of these estimated effects support a clear and consistent understanding of the way food environments change after countries join a U.S. FTA: sales of all types of processed products increase, while no change occurs in sales of minimally processed or unprocessed foods. In statistical models, large variations in country-specific random intercepts and slopes were observed, suggesting that additional unmeasured factors impact sales of these products and that countries do not respond uniformly to entry into a U.S. FTA.

Aim 3

This study was a critical review of the quantitative literature on global trade and investment and diet, tobacco, alcohol, and related health outcomes, with the intention of developing recommendations and providing resources to guide future robust and policy relevant research. A review of reviews, expert review, and reference tracing were employed to identify relevant quantitative studies, which were evaluated using a novel quality assessment tool, developed based on the findings of previous reviews. Eight review articles and 34 quantitative studies were identified for inclusion in the study. Of 34 quantitative studies, 18 examined at least one NCD-related health outcome, either

morbidity or mortality; ten assessed changes in one or more aspects of dietary intake; nine examined average BMI or the prevalence of overweight or obesity. Tobacco and alcohol consumption were the object of only three studies and one study, respectively. Three out of 34 studies used natural experiment designs, with one employing synthetic controls.

Three areas of consensus across the eight review articles were confirmed in this assessment of strengths and weaknesses of quantitative studies: the need to clearly define exposures of interest and not conflate trade and investment; the lack of exploration of mechanisms of these relationships; and the limited use of individual-level data. Additional ways to improve the robustness of future studies were identified: consensus and consistency in the choice of key confounding variables; the potential to utilize more sector-specific versus economy-wide trade and investment indicators; the need to test and adequately adjust for autocorrelation and endogeneity when using longitudinal data; and the importance of presenting results from alternative statistical models and sensitivity analyses, given the lack of consensus regarding several methodological decisions.

Summary of thesis findings: key themes

Increases in NCD risk factors following liberalization

As hypothesized, the findings of both quantitative studies generally supported the conclusion that global trade and investment liberalization facilitate an increase in selected NCD risk factors. Aim 1 identified steady increases in tobacco and alcohol consumption after countries joined the WTO; Aim 2 found sales of processed foods and beverages, including baby foods (the NCD-related impacts of which are not entirely clear), increased after countries joined a U.S. FTA. Thus, these two empirical analyses lend additional

support for the argument that global trade and investment are important social determinants of the worldwide NCD epidemic.

Need for additional quantitative research on trade, investment, and alcohol

The results of Aim 1 indicate that trade liberalization can contribute to increases in alcohol consumption, yet the review in Aim 3 identified only one quantitative study to date that has investigated this outcome. Additional quantitative research investigating the relationship between global trade and investment and alcohol use is warranted.

Country-specific variation in responses to liberalization

The statistical models estimated in both Aims 1 and 2 identified large variations in country-specific random effects, suggesting additional country-level factors also explain patterns in NCD risk factors and their relationships to trade and investment liberalization. These country-specific determinants may include relatively permanent characteristics, such as geographic location, climate, and the religious composition of the population, as well as unpredictable events such as abrupt political changes or natural disasters. Such events can dramatically alter trading and investment relationships, the flow of imports and exports, agricultural productivity, levels of disposable income, and many other societal and household characteristics that affect consumption. Given the likely critical role of country-specific factors in determining the impacts of trade and investment policies on tobacco, alcohol, and dietary consumption, additional research at the country level is warranted.

Need for exploration of mechanisms linking trade and investment to NCD risk factors

Related to the issue of country-specific variation is the importance of investigating mechanisms of these relationships more generally. The review in Aim 3

found that only six of 34 studies attempted any statistical exploration of possible mechanisms underlying primary exposure-outcome relationships investigated in each study. Investigating these mechanisms was beyond the scope of this research, and could be considered weaknesses of the study designs used in Aims 1 and 2, the conclusions of which could be refined with greater exploration of possible mediating and moderating factors. As pointed out by Barlow, et al., dichotomous indicators signifying entry into force of an agreement treat these as "black boxes," providing no understanding of which specific policies account for outcomes (99). Thus, improved understanding of mechanisms remains an important area for future work.

Potential for greater application of natural experiment study designs

The empirical analyses in Aims 1 and 2 illustrate the utility of natural experiment designs for this topic, which strengthen the ability to draw causal inferences from observational data. The review in Aim 3 identified only three previous studies that used this approach to investigate relationships between trade and investment and tobacco, alcohol, diet, or related health outcomes, indicating there is substantial scope to expand the use of natural experiments in this area of research.

Implications for research and policy

Research

Several of the key themes from the study findings, presented above, have direct implications for future research on global trade and investment and NCD risk factors: the need for additional research on alcohol, country-specific variations, and mechanisms, and expanding the use of natural experiment designs. In addition, inconsistent or unexpected

findings in the two empirical analyses point to other areas for future research, as do key gaps in the literature identified by the critical review. Each of these is elaborated below.

The analysis in Aim 1 found a steady increasing average trend in alcohol consumption in countries after WTO accession, compared to weighted unexposed countries. This aligns with the only previous longitudinal analysis on this topic, which found a positive correlation between FDI (relative to GDP) and alcohol sales in 50 low- and middle-income countries (26), as well as concerns raised by other authors about the implications of trade and investment agreements for alcohol control (225)(67). One possible approach for future quantitative research on this topic would be to explore the relationship between applied tariff rates for one or more alcohol products and alcohol sales or consumption. This relationship should also be investigated in the context of agreements other than the WTO and expanded to countries not included in these two existing assessments. Illicit trade in alcohol is difficult to measure and may be an important limitation to research on this topic (232) or an area for additional exploration in the context of global trade and investment.

While country- or region-specific research comprises much of the existing trade, investment and health literature, these analyses predominantly present only descriptive data and do not include statistical analysis – see, for example, Thow & Hawkes (2009) (57) and Drope & Chavez (2015) (233). Studies of this type could be expanded to include regression analysis that explores similar explanatory variables as investigated in international panel analyses, but with greater nuance for one or a few countries. Such analyses would be strengthened by the inclusion of additional country-specific confounding variables, which can elucidate possible mediating and moderating events,

conditions, and policies, not captured in analyses of large multi-country samples. These types of case studies can then generate new hypotheses to investigate for their generalizability to larger groups of countries.

Country-specific research is closely tied to research that explores possible mechanisms linking trade and investment to specific risk factors, as this also requires detailed information that may not be available or comparable across countries. Possible mechanisms that could plausibly be explored using internationally comparable data include: the number and type of retail outlets; product prices; market shares of foreign versus domestic brands; and implementation of particular policies designed to deter consumption of high-risk products, among other examples.

Natural experiment designs have only recently been applied to this topic, with the first study of this kind published in 2015 (63). This first study and the other published analyses using natural experiment designs have investigated membership in: the WTO (63) and U.S. FTAs (62), including the North American Free Trade Agreement (64). Between these three studies and the two empirical analyses in this dissertation, which also investigated the WTO and U.S. FTAs, a wide range of other agreements are as yet unexplored using this approach. In particular, no published study has used a natural experiment design to examine the impacts of an investment agreement on NCD risk factors.

Key questions for future research generated by the analysis in Aim 1 include investigating why similar effects of joining the WTO on either fruits and vegetables (immediate increase) or sugar (initial decrease followed by gradual increase) were not observed for other categories of agricultural products. Second, the finding that alcohol

and tobacco consumption increased requires additional exploration to understand whether existing users are consuming more or new users are drawn to these products, which have different implications for public health and policy. Third, treatment effects suggested by graphical results but not supported by statistical models could be further investigated: increases in seafood and red meat and animal fat consumption following WTO accession. Fourth, the significant reduction in tobacco consumption associated with ratification of the FCTC should be confirmed and further explored. Finally, because treatment effects in this analysis were not consistently significant overall, exploration of possible moderating factors, such as country income level, or additional confounding factors, is warranted.

The findings in Aim 2 point to the need to further understand the impacts of membership in other trade and investment agreements (aside from U.S. FTAs) for processed food sales. Estimated coefficients on variables for membership in trade and investment agreements with the EU and Switzerland and U.S. investment treaties were highly variable across outcomes, suggesting inconsistent relationships. These may be important only for selected outcomes, likely those for which corporations with headquarters in the partner country have a dominant role in the relevant industry. Second, across model variations for all outcomes, estimated post-treatment changes in the intercept and slope were often contradictory, i.e., one was positive and the other was negative. This may reflect variation across countries in the speed at which the impacts of trade liberalization take effect, further supporting the need to explore country-specific factors affecting the impacts of liberalization. Third, the finding that baby food consumption increased after joining a U.S. FTA requires better understanding. This may be either negative or positive for child health, depending on whether baby food is used

instead of breast milk, to which it is nutritionally inferior, or in place of less appropriate substitute foods not designed for infants, over which it is an improvement.

In addition to the recommendations for future research, described above, the review in Aim 3 identified several gaps in the existing literature. First, many relevant quantitative studies were not covered by previous reviews, suggesting a more traditional review focused on the magnitude and consistency of measured effects may be warranted to complement the methodological focus of that study. Second, no studies were identified that used the *prevalence* of tobacco or alcohol use as outcomes (instead only examining sales or consumption), which is important to explore in the context of trade and investment liberalization. Third, childhood obesity, a risk factor for NCDs in adulthood (220), has also not been explored in relation to global trade and investment and could be an important area of investigation. Fourth, more studies should examine morbidity due to specific NCDs or NCD-related mortality as outcomes, underutilized to date compared to the large number of studies examining life expectancy and all-cause mortality as outcomes. Lastly, quantitative research has not yet attempted to compare the effects of different trade and investment agreements based on the depth of commitments involved, which could be a useful area for exploration.

In addition to the major implications for future research outlined in the preceding section, the translation of this research *to* policy is also critical. However, educating policymakers, advocates, and other audiences about relationships between trade and investment policy and health is complicated by the interdisciplinary nature of the topic. Health audiences must learn new terminology and concepts about global trade and investment and trade and investment audiences must likewise be introduced to public

health. The "health in all policies" framework, endorsed by WHO, offers a set of strategies to bridge health and other sectors, one of which is to "strengthen the capacity of Ministries of Health to engage other sectors of government" (234).

Policy

The implication of this research is not that global trade and investment should be opposed, but rather, that public health concerns must be accorded sufficient consideration alongside trade and investment. Trade and investment treaties constitute sets of legally binding commitments, which may not permit substantial flexibility to simultaneously pursue health policy objectives (71). When in conflict, this can result in a trade or investment dispute, wherein a country or corporation sues a government over implementation of a policy that threatens its profits. The tobacco company Philip Morris's lawsuits against the governments of Australia and Uruguay (235)(236) over policies requiring plain-packaging for cigarettes are two often-cited examples of this type of conflict.

Three types of policy decisions are particularly relevant to prioritize public health in this context: prospectively considering potential health risks when designing new trade and investment agreements; preserving policy space to implement health-promoting policies, even if these may have restrictive effects on trade or investment; and protecting such policies in trade and investment disputes. These require important actions at both global and national levels, discussed below. As this research was conducted in the U.S., unique policy implications for the U.S. perspective are also considered.

Global policies

The primary role of global-level policy in this context is to develop and endorse standards and provide legal justification for national health policies that may otherwise conflict with trade or investment commitments and could be threatened in a dispute. This can include amendments to trade and investment agreements and health *treaties*, which bind parties to specific commitments, as well as global *guidelines*, which are non-binding; but arbitration panels are nonetheless likely to weigh during trade and investment dispute settlement. Global policies of these types, which help to ensure trade and investment policies do not undermine health policies, align with the commitment to "policy coherence for sustainable development," enshrined in the United Nations Sustainable Development Goals (SDGs) (186).

There is one example of a health treaty relevant to NCDs: the Framework Convention on Tobacco Control (FCTC), which came into force in 2005. While the FCTC could be strengthened in its language on trade and investment (237), it nonetheless provides important legal validation for countries' tobacco control measures. The findings in Aims 1 and 2 that trade liberalization may lead to increases in alcohol and processed food consumption lend support for calls to consider adopting health treaties on these topics as well. International agreements on alcohol (238) and the marketing of junk food to children (239) have been proposed, as has a broader *Framework Convention on Global Health* (240). Currently, the *Global strategy on diet, physical activity, and health* and the *Global strategy to reduce the harmful use of alcohol* are the leading global instruments governing policies for diet and alcohol, respectively, but neither contain binding commitments (241).

An example of a second type of global policy tool – international standards or guidelines – is the *Codex Alimentarius* International Food Standards (242), which are maintained by WHO and the Food and Agriculture Organization (FAO). These provide guidelines for nutrition labeling, among other food-related topics, and can act as a template for national legislation on these topics. Furthermore, specific agreements of the WTO obligate countries to base policies on relevant *Codex* standards, if available, giving these "far reaching implications for resolving trade disputes" (242). Thus, adding new policies to *Codex* guidelines, or to similar international guidelines regarding tobacco and alcohol policies, provides a means to establish their legitimacy if challenged for possible restrictive impacts on trade or investment.

A third option, which would require substantial political will and may therefore be unrealistic, is amending existing trade and investment agreements to achieve specific public health objectives, such as allowing greater policy space to discourage tobacco, alcohol, or processed food consumption. For example, agreements could be amended to remove tobacco or tobacco products from their scope. While it may be too difficult in most cases to retroactively insert such exemptions into existing agreements, including these measures in future agreements is an important means by which countries can begin to address negative health impacts of trade and investment, as described below.

National-level policies

A key opportunity at the national level is for countries to choose to evaluate possible health implications of new trade and investment agreements during the negotiation phase. Agreements can then be adapted to maximize benefits and minimize harms to public health, for example through "carve-outs" or exemptions (181) for

harmful products or by broadening health-related exceptions to specific commitments (243). Health impact assessment (HIA) is one tool to prospectively assess potential positive and negative health effects of a proposed decision; at least two HIAs of trade agreements have been conducted – for the Trans-Pacific Partnership (77) and the Trans-Atlantic Trade and Investment Partnership (76). In addition, countries can involve health experts in the negotiation of new agreements so a health perspective is incorporated throughout the process; Thailand provides a successful example of this (244).

Overall, national representatives to trade and investment agreement negotiations must be informed of potential impacts on the health of their populations. Whether through recommendations from an HIA or input from health experts, the specific risks of proposed agreements should be identified. The findings of this research suggest that provisions governing tobacco, alcohol, and processed foods may be key vulnerabilities for increasing exposure to major risk factors. To minimize these risks, negotiators should consider refusing to reduce tariffs or pursuing exemptions specific to these products. In addition, agriculture-related provisions should be carefully assessed, to ensure that local producers are not disadvantaged through competition from imports sold at artificially low prices due to subsidized production in other countries.

National governments – as well as subnational jurisdictions – also have an important role in influencing norms by implementing and sustaining policies to combat consumption of tobacco, alcohol, and nutrient-poor foods. It becomes more difficult to challenge policies that are in place in more jurisdictions – both because of the resources required for multiple legal battles, but also because policies gain acceptance. Furthermore, while corporations may file legal challenges through private court systems

(via ISDS), national governments can elect not to dispute the implementation of these types of policies in partner countries, thereby allowing them to be upheld.

U.S. policies

In addition to general national-level policies, described above, there are specific implications for U.S. policy, given its dominant position in global trade and investment. The U.S. is well placed to take more of a leadership role in both research and policy on this topic – by funding research on the health impacts of global trade and investment and by raising its standards for health protections in the agreements it negotiates. The U.S. is home to many leading transnational tobacco, alcohol, and food and beverage corporations, whose sales are facilitated by trade and investment agreements and contribute to NCDs. Despite this, the vast majority of research on the health impacts of global trade and investment have not been conducted or funded by U.S.-based institutions or researchers; Canada, Australia, and the U.K. have led in this area.

In the U.S., concerns about the environmental and labor impacts of trade and investment agreements have received comparatively more attention, but health continues to be a neglected topic in this context. This is exemplified in the Office of the United States Trade Representative's (USTR) recently released priorities for renegotiation of the North American Free Trade Agreement (NAFTA) (245). These contain a set of objectives specific to both labor and environment, including the establishment of a "senior-level" committee dedicated to each, but no section on health. The American Public Health Association has advocated for public health concerns to be accorded greater priority in trade and investment (246). This could include establishing a trade advisory committee (247) with public health expertise or including greater exceptions for

health objectives in U.S. model treaties (248), which serve as the basis for future negotiations. The Executive Order requiring environmental impact assessments of proposed trade agreements (249) could also be amended to require health impact assessments of all proposed trade and investment agreements.

Strengths and weaknesses of this thesis research

Strengths

An overarching strength of this research is that it addresses a topic with broad implications for public health that is relatively under-researched. Global trade and investment liberalization are important social determinants of health that require further understanding, and this research advances knowledge of these impacts and the methods for investigating these topics.

A key strength of the two empirical analyses is the use of natural experiment designs as well as matching or weighting of unexposed countries, both of which help to address limitations of observational data. Another key strength of these studies is the use of specific outcomes that are highly relevant for NCD prevention and control. These analyses consider whether particular food groups, as well as tobacco and alcohol, are impacted by new trade agreements, generating more useful information for policy than studies, for example, that simply examine obesity prevalence as an outcome. As is evident from the critical review in Aim 3, these features make for more robust study designs than the majority of quantitative studies on these topics to date, providing high quality evidence of these relationships and helping to advance methodological standards in this literature.

A strength of the critical review is its comprehensiveness – studies were identified from a review of reviews, expert consultation, and reference tracing. From this broad search strategy, 34 quantitative studies were identified for inclusion, a substantially larger number than previous reviews with a focus on quantitative research in this area. Another important strength of the review is the development and application of a novel quality assessment tool, specifically designed to assess suspected limitations of studies on these topics. Through this approach to quality assessment, an inventory of the proportion of studies with various characteristics was compiled for the first time for this topic area, providing a resource for the construction of novel and robust analyses in the future.

Weaknesses

A possible weakness of this research is that its assumptions and hypotheses may be premised on existing arguments driven more by ideology than objective evidence. The interests of the stakeholders involved in this topic area – notably, industry and others with large financial stakes on the one hand, and health, environmental, and labor advocates, on the other – can lead to a dialogue skewed by interests rather than facts. However, this was also a motivation for this work – to contribute objective analysis and identify ways to strengthen this body of research – and the attempt throughout has been to maintain objectivity in the design and analysis of each study. Possible limitations of the validity and reliability of study findings are discussed below.

A key threat to the validity of the quantitative analyses is that the true quantity critical to the development of NCDs is *consumption* of the selected outcomes; however, the data examined are proxies for consumption: in Aim 1, *supply,* and in Aim 2, *sales*. While these data are imperfect reflections of the true quantities of interest, they are the

best available information for these research questions, particularly given the problems of recall bias (250) and cross-country comparability (251) that complicate data from consumption surveys. A further limitation of the quantities of tobacco and alcohol used in Aim 1 is that these do not capture consumption from homemade products or illicit sales, which may be substantial for both products in certain countries. However, this is a limitation of research on global tobacco and alcohol consumption generally and not unique to this study. Additional weaknesses arise from the quality of data utilized for each study: certain data points were modelled or missing. To limit possible impacts of unreliable data, various sensitivity analyses were used in each study to explore the influence of substantial missingness or modelling in the outcome data.

As with all research that attempts to link macro-level factors to individual behaviors and outcomes, confounding factors – at various intervening levels – cannot be ruled out as possible explanations, and pose additional threats to the validity of findings. The possibility of confounding is also exacerbated by the inability to conduct randomized experiments for trade and investment exposures. Several aspects of the design and analysis were incorporated to help overcome these limitations: multiple exposed units, natural experiment designs, comparative interrupted time-series analysis, weighting or matching of the unexposed units, and adjustment for known confounders in statistical models. Each of these helps to limit the possibility that one or more confounding factors explains observed relationships.

The external validity of the two empirical analysis is limited by the countries and agreements included in each study. In the first study, the selection of exposed and unexposed units was limited to countries that were not original members of the WTO. In

the second study, exposed units were limited to selected U.S. FTA partner countries with available data. For both studies, it is possible that similar analyses with different groups of countries would not yield the same conclusions. Furthermore, conclusions may be valid only for the specific type of agreement investigated in each study (WTO and U.S. FTA, respectively) and not replicable for other trade or investment agreements.

The most important threat to the validity of the findings and conclusions of the third study is publication bias. There may be a bias against the publication of research on these topics that produced negative or null results; to limit this influence, articles from the grey literature, including working papers, conference presentations, and graduate work were all eligible for inclusion. Furthermore, the focus of this study was on the methods, as opposed to the results, of existing studies, so any positive or negative skew of study findings (the likely impact of publication bias) was not of primary interest.

An additional threat to validity and the greatest threat to the reliability of the third study is subjectivity. Biases in the authors' reading and evaluation of the literature may limit the conclusions to this unique perspective. Other authors may draw different conclusions from the same set of studies and even the same researchers could extract different information from the included studies, if repeated. To minimize this influence and offer a means to replicate the study, a uniform quality assessment tool was developed and applied to all included studies to standardize the way these were evaluated and the information extracted from each.

Conclusion

This thesis research reviews, advances, and contributes quantitative research examining global trade and investment liberalization as macro-level determinants of the global NCD epidemic, through the key risk factors of dietary, tobacco, and alcohol consumption. Two natural experiments provide evidence that joining the WTO leads to increases in tobacco and alcohol consumption and joining a U.S. FTA causes sales of highly processed foods and beverages to increase. Each of these impacts can contribute to the growing prevalence of several leading NCDs that comprise a dominant proportion of the global disease burden. A critical review of quantitative research examining the impacts of trade and investment policies on diet, tobacco, alcohol, and related health outcomes identified important limitations of 34 completed studies to date and ways to improve the robustness and policy relevance of future research on these topics. The major implications of this research are twofold. First, that understanding of the health impacts of global trade and investment must be advanced through additional research. Second, that protections for public health should be incorporated in both the interpretation and application of existing trade and investment agreements and in the design of future agreements, and supported by global health policies.

Appendix A: Variables and data sources (Aims 1 and 2)

Variable	Description	Data source
Country	Country name	UN
Country ISO	3-digit country ISO code	UN
Year	4-digit year	n/a
Region	WB regional classification (East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, Sub-Saharan Africa)	WB WDI
Income group	WB income group classification (low, lower-middle, upper-middle, high)	WB WDI
EU member	Indicator variable signifying whether country is a member of the European Union	EU
Former USSR	Indicator variable signifying whether country was a USSR member state	Encyclopedia Britannica
Total population UN	Total population, in 1000s	UNPOP WPP
Total population, FAO	Total population, in 1000s	FAO
Population 15+	Total population aged 15 and older, in 1000s	UNPOP WPP
Population under 5	Total population aged 5 and under, in 1000s	UNPOP WPP
Urbanization rate	Percent of population living in an urban area (as defined by national statistical offices)	UNPOP WUP
GDP pc, 2005 ID	Gross domestic product per capita in 2005 international dollars	IHME
GDP pc, current ID	Gross domestic product per capita in current international dollars	IMF WEO
FLFP 15+, ILO	Female labor force participation rate, aged 15+, from International Labor Organization	WB WDI
FLFP 15+, National	Female labor force participation rate, aged 15+, national estimate	WB WDI
Muslim population	Percent of the population identifying as Muslim	Pew Research Center
Polity	Scale classifying national government from fully autocratic (-10) to fully democratic (+10)	Polity Project
WTO member	WTO member: ranges from 0 (non-member) to 1 (member), fraction represents number of days of membership in year of joining	WTO
WTO joining date	Date on which country joined the World Trade Organization	WTO
GATT member	Indicator variable signifying whether country was a member of the General Agreement on Tariffs and Trade	WTO
FCTC ratification date	Date on which the Framework Convention on Tobacco Control was ratified, accepted, approved, confirmed, or acceded or succeeded to, by the country	UN Treaty Collection
FCTC ratified	Framework Convention on Tobacco Control ratified: ranges from 0 (not ratified) to 1 (ratified), fraction represents number of days ratified in year of ratification	UN Treaty Collection
US FTA date	Date of entry into force of free trade agreement with United States	USTR

US FTA in force	US free trade agreement in force: ranges from 0 (not in force) to 1 (in force), fraction represents number of days in force in year of entry into force	USTR
Switzerland FTA date	Date of entry into force of free trade agreement with Switzerland	Switzerland SECO
Switzerland FTA in force	Switzerland free trade agreement in force: ranges from 0 (not in force) to 1 (in force), fraction represents number of days in force in year of entry into force	Switzerland SECO
EU FTA date	Date of entry into force of free trade agreement with European Union	European Commission
EU FTA in force	EU free trade agreement in force: ranges from 0 (not in force) to 1 (in force), fraction represents number of days in force in year of entry into force	European Commission
US BIT date	Date of entry into force of bilateral investment treaty with United States	US Office of Trade Agreement Negotiations and Compliance
US BIT in force	US bilateral investment treaty in force: ranges from 0 (not in force) to 1 (in force), fraction represents number of days in force in year of entry into force	US Office of Trade Agreement Negotiations and Compliance
Switzerland BIT date	Date of entry into force of bilateral investment treaty with Switzerland	UNCTAD
Switzerland BIT in force	Switzerland bilateral investment treaty in force: ranges from 0 (not in force) to 1 (in force), fraction represents number of days in force in year of entry into force	UNCTAD
EU IIA date	Date of entry into force of international investment agreement with the European Union	UNCTAD
EU IIA in force	EU international investment agreement in force: ranges from 0 (not in force) to 1 (in force), fraction represents number of days in force in year of entry into force	UNCTAD
Tobacco, all forms	Annual national supply in tonnes	FAO
Alcoholic beverages	Annual national supply in thousands of tonnes	FAO
Apples and products	Annual national supply in kilograms per capita	FAO
Aquatic plants	Annual national supply in kilograms per capita	FAO
Bananas	Annual national supply in kilograms per capita	FAO
Citrus, other	Annual national supply in kilograms per capita	FAO
Coconuts including Copra	Annual national supply in kilograms per capita	FAO
Dates	Annual national supply in kilograms per capita	FAO
Fruits, other	Annual national supply in kilograms per capita	FAO
Grapefruit and products	Annual national supply in kilograms per capita	FAO
Grapes and products, excluding wine	Annual national supply in kilograms per capita	FAO
Lemons, limes, and products	Annual national supply in kilograms per capita	FAO
Olives, including preserved	Annual national supply in kilograms per capita	FAO
Onions	Annual national supply in kilograms per capita	FAO
Oranges and mandarins	Annual national supply in kilograms per capita	FAO

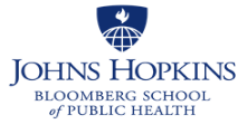
Pimento	Annual national supply in kilograms per capita	FAO
Pineapple and products	Annual national supply in kilograms per capita	FAO
Tomatoes and products	Annual national supply in kilograms per capita	FAO
Vegetables, other	Annual national supply in kilograms per capita	FAO
Beans	Annual national supply in kilograms per capita	FAO
Groundnuts, shelled equivalent	Annual national supply in kilograms per capita	FAO
Nuts and products	Annual national supply in kilograms per capita	FAO
Oil crops, other	Annual national supply in kilograms per capita	FAO
Palm kernels	Annual national supply in kilograms per capita	FAO
Peas	Annual national supply in kilograms per capita	FAO
Pulses, other, and products	Annual national supply in kilograms per capita	FAO
Rape and mustard seed	Annual national supply in kilograms per capita	FAO
Sesame seed	Annual national supply in kilograms per capita	FAO
Soya beans	Annual national supply in kilograms per capita	FAO
Sunflower seed	Annual national supply in kilograms per capita	FAO
Aquatic animals, other	Annual national supply in kilograms per capita	FAO
Cephalopods	Annual national supply in kilograms per capita	FAO
Crustaceans	Annual national supply in kilograms per capita	FAO
Demersal fish	Annual national supply in kilograms per capita	FAO
Fish, body oil	Annual national supply in kilograms per capita	FAO
Fish, liver oil	Annual national supply in kilograms per capita	FAO
Freshwater fish	Annual national supply in kilograms per capita	FAO
Marine fish, other	Annual national supply in kilograms per capita	FAO
Mollusks, other	Annual national supply in kilograms per capita	FAO
Pelagic fish	Annual national supply in kilograms per capita	FAO
Bovine meat	Annual national supply in kilograms per capita	FAO
Butter and ghee	Annual national supply in kilograms per capita	FAO
Cream	Annual national supply in kilograms per capita	FAO
Fats, animal, raw	Annual national supply in kilograms per capita	FAO
Meat, other	Annual national supply in kilograms per capita	FAO
Mutton and goat meat	Annual national supply in kilograms per capita	FAO
Offals, edible	Annual national supply in kilograms per capita	FAO
Pigmeat	Annual national supply in kilograms per capita	FAO
Honey	Annual national supply in kilograms per capita	FAO
Sugar, raw equivalent	Annual national supply in kilograms per capita	FAO
Sugarbeet	Annual national supply in kilograms per capita	FAO
Sugarcane	Annual national supply in kilograms per capita	FAO
Sugar, non-centrifugal	Annual national supply in kilograms per capita	FAO
Sweeteners, other	Annual national supply in kilograms per capita	FAO
Barley and products	Annual national supply in kilograms per capita	FAO
Cassava and products	Annual national supply in kilograms per capita	FAO
Cereals, other	Annual national supply in kilograms per capita	FAO

Maize and products	Annual national supply in kilograms per capita	FAO
Millet and products	Annual national supply in kilograms per capita	FAO
Oats	Annual national supply in kilograms per capita	FAO
Plantains	Annual national supply in kilograms per capita	FAO
Potatoes and products	Annual national supply in kilograms per capita	FAO
Rice, milled equivalent	Annual national supply in kilograms per capita	FAO
Roots, other	Annual national supply in kilograms per capita	FAO
Rye and products	Annual national supply in kilograms per capita	FAO
Sorghum and products	Annual national supply in kilograms per capita	FAO
Sweet potatoes	Annual national supply in kilograms per capita	FAO
Wheat and products	Annual national supply in kilograms per capita	FAO
Yams	Annual national supply in kilograms per capita	FAO
Coconut oil	Annual national supply in kilograms per capita	FAO
Cottonseed oil	Annual national supply in kilograms per capita	FAO
Groundnut oil	Annual national supply in kilograms per capita	FAO
Maize germ oil	Annual national supply in kilograms per capita	FAO
Oil crops, other oil	Annual national supply in kilograms per capita	FAO
Olive oil	Annual national supply in kilograms per capita	FAO
Palm oil	Annual national supply in kilograms per capita	FAO
Palm kernel oil	Annual national supply in kilograms per capita	FAO
Rape and mustard seed oil	Annual national supply in kilograms per capita	FAO
Ricebran oil	Annual national supply in kilograms per capita	FAO
Sesame seed oil	Annual national supply in kilograms per capita	FAO
Soya bean oil	Annual national supply in kilograms per capita	FAO
Sunflower seed oil	Annual national supply in kilograms per capita	FAO
Eggs	Annual retail sales in 1000s of tonnes	Euromonitor
Fish and seafood	Annual retail sales in 1000s of tonnes	Euromonitor
Fruits	Annual retail sales in 1000s of tonnes	Euromonitor
Meat	Annual retail sales in 1000s of tonnes	Euromonitor
Nuts	Annual retail sales in 1000s of tonnes	Euromonitor
Pulses	Annual retail sales in 1000s of tonnes	Euromonitor
Starchy roots	Annual retail sales in 1000s of tonnes	Euromonitor
Vegetables	Annual retail sales in 1000s of tonnes	Euromonitor
Butter and margarine	Annual retail sales in 1000s of tonnes	Euromonitor
Drinking milk products	Annual retail sales in 1000s of tonnes	Euromonitor
Oils and fats	Annual retail sales in 1000s of tonnes	Euromonitor
Other dairy	Annual retail sales in 1000s of tonnes	Euromonitor
Processed fruits and vegetables	Annual retail sales in 1000s of tonnes	Euromonitor
Rice, pasta, and noodles	Annual retail sales in 1000s of tonnes	Euromonitor
Sugar and sweeteners	Annual retail sales in 1000s of tonnes	Euromonitor
Baked goods	Annual retail sales in 1000s of tonnes	Euromonitor
Breakfast cereals	Annual retail sales in 1000s of tonnes	Euromonitor
Cheese	Annual retail sales in 1000s of tonnes	Euromonitor

Chocolate confectionary	Annual retail sales in 1000s of tonnes	Euromonitor
Ice cream and frozen desserts	Annual retail sales in 1000s of tonnes	Euromonitor
Processed meat and seafood	Annual retail sales in 1000s of tonnes	Euromonitor
Ready meals	Annual retail sales in 1000s of tonnes	Euromonitor
Sauces, dressings, and condiments	Annual retail sales in 1000s of tonnes	Euromonitor
Savory snacks	Annual retail sales in 1000s of tonnes	Euromonitor
Soup	Annual retail sales in 1000s of tonnes	Euromonitor
Spreads	Annual retail sales in 1000s of tonnes	Euromonitor
Sugar confectionary	Annual retail sales in 1000s of tonnes	Euromonitor
Sweet biscuits, snack bars, and fruit snacks	Annual retail sales in 1000s of tonnes	Euromonitor
Yogurt and sour milk products	Annual retail sales in 1000s of tonnes	Euromonitor
Carbonates	Annual retail sales in millions of liters	Euromonitor
Concentrates	Annual retail sales in millions of liters	Euromonitor
Juice	Annual retail sales in millions of liters	Euromonitor
Ready-to-drink coffee	Annual retail sales in millions of liters	Euromonitor
Ready-to-drink tea	Annual retail sales in millions of liters	Euromonitor
Sports and energy drinks	Annual retail sales in millions of liters	Euromonitor
Baby food	Annual retail sales in 1000s of tonnes	Euromonitor

**UN = United Nations; WB WDI = World Bank World Development Indicators; EU = European Union; UNPOP WPP = United Nations Population Division World Population Prospects; FAO = Food and Agriculture Organization; IHME = Institute for Health Metrics and Evaluation; IMF WEO = International Monetary Fund World Economic Outlook; WTO = World Trade Organization; USTR = Office of the United States Trade Representative; SECO = State Secretariat for Economic Affairs; UNCTAD = United Nations Conference on Trade and Development*

Appendix B: JHSPH Institutional Review Board determination notice



FWA #00000287

Institutional Review Board Office

615 N. Wolfe Street / Room E1100
Baltimore, Maryland 21205-2179
Phone: 410-955-3193
Toll Free: 1-888-262-3242
Fax: 410-502-0584
Email: jhsph.irboffice@jhu.edu
Website: www.jhsph.edu/irb

NOT HUMAN SUBJECTS RESEARCH
DETERMINATION NOTICE
STUDENT PROJECTS

Date: January 19, 2016

To: Krycia Cowling

Re: **PhD Dissertation Student Project Title:** "The impact of global trade liberalization on tobacco, alcohol, and dietary consumption"

The JHSPH IRB reviewed the IRB Office Determination Request Form for Secondary Data Analysis (received 1/14/16) on **January 19, 2016**. We have determined that the proposed activity described in your request form will involve secondary data analysis of existing, de-identified/de-linked publicly available datasets. Thus, the proposed activity does not qualify as human subjects research as defined by DHHS regulations 45 CFR 46.102, and does not require IRB oversight.

You are responsible for notifying the JHSPH IRB of any future changes that might involve human subjects and require IRB review.

If you have any questions regarding this determination, please contact the JHSPH IRB Office at (410) 955-3193 or via email at jhsph.irboffice@jhu.edu.

/teb

cc Keshia Pollack, PhD
Faculty Advisor / Associate Professor
Department of Health Policy and Management
Johns Hopkins University School of Public Health

Appendix C: Construction of outcome variables (Aim 1)

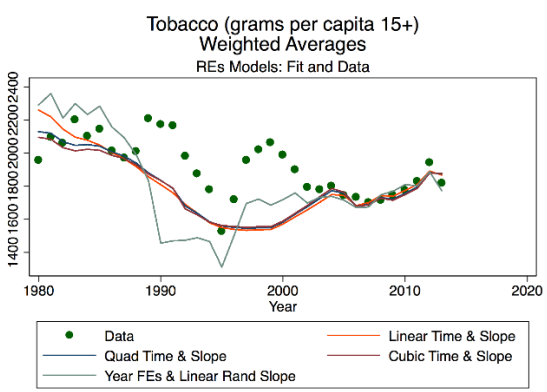
Outcome	Data element	Percent missing (across 47 countries included in analysis)
Alcohol	Alcoholic beverages	1.63%
Edible oils	Coconut Oil	26.78%
Edible oils	Cottonseed oil	39.71%
Edible oils	Groundnut oil	16.48%
Edible oils	Maize Germ Oil	23.80%
Edible oils	Oil crops Oil, Other	1.63%
Edible oils	Olive Oil	7.88%
Edible oils	Palm Oil	37.71%
Edible oils	Palmkernel Oil	64.00%
Edible oils	Rape and Mustard Oil	24.01%
Edible oils	Ricebran oil	88.00%
Edible oils	Sesame seed oil	30.04%
Edible oils	Soyabean oil	4.05%
Edible oils	Sunflower seed oil	11.22%
Fruits & vegetables	Apples and products	1.63%
Fruits & vegetables	Aquatic Plants	8.88%
Fruits & vegetables	Bananas	7.10%
Fruits & vegetables	Citrus, Other	23.93%
Fruits & vegetables	Coconuts, including Copra	9.45%
Fruits & vegetables	Dates	23.65%
Fruits & vegetables	Fruits, Other	1.63%
Fruits & vegetables	Grapefruit and products	16.62%
Fruits & vegetables	Grapes and products, excluding wine	6.46%
Fruits & vegetables	Lemons, Limes and products	15.27%
Fruits & vegetables	Olives (including preserved)	18.96%
Fruits & vegetables	Onions	13.57%
Fruits & vegetables	Oranges, Mandarins	1.63%
Fruits & vegetables	Pimento	22.16%
Fruits & vegetables	Pineapples and products	9.52%
Fruits & vegetables	Tomatoes and products	4.05%
Fruits & vegetables	Vegetables, Other	1.63%
Nuts, seeds, & legumes	Beans	28.91%
Nuts, seeds, & legumes	Groundnuts (shelled equivalent)	10.44%
Nuts, seeds, & legumes	Nuts and products	1.63%
Nuts, seeds, & legumes	Oil crops, Other	54.62%
Nuts, seeds, & legumes	Palm kernels	86.43%
Nuts, seeds, & legumes	Peas	31.53%
Nuts, seeds, & legumes	Pulses, Other and products	4.69%
Nuts, seeds, & legumes	Rape and Mustard seed	27.91%
Nuts, seeds, & legumes	Sesame seed	45.24%
Nuts, seeds, & legumes	Soyabeans	13.49%
Nuts, seeds, & legumes	Sunflower seed	63.99%
Red meat & animal fats	Bovine Meat	1.63%
Red meat & animal fats	Butter, ghee	1.63%
Red meat & animal fats	Cream	21.52%
Red meat & animal fats	Fats, animals, raw	3.13%

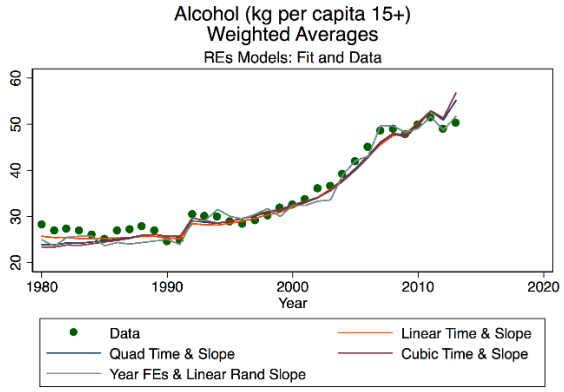
Red meat & animal fats	Meat, Other	1.63%
Red meat & animal fats	Mutton & Goat Meat	1.63%
Red meat & animal fats	Offals, Edible	1.63%
Red meat & animal fats	Pigmeat	8.74%
Seafood	Aquatic Animals, Others	24.64%
Seafood	Cephalopods	4.05%
Seafood	Crustaceans	4.05%
Seafood	Demersal fish	4.05%
Seafood	Fish, body oil	19.11%
Seafood	Fish, liver oil	37.00%
Seafood	Freshwater Fish	1.63%
Seafood	Marine Fish, Other	6.46%
Seafood	Mollusks, Other	4.05%
Seafood	Pelagic Fish	4.05%
Starches	Barley and products	6.46%
Starches	Cassava and products	34.45%
Starches	Cereals, Other	3.20%
Starches	Maize and products	1.63%
Starches	Millet and products	68.40%
Starches	Oats	19.18%
Starches	Plantains	57.67%
Starches	Potatoes and products	1.63%
Starches	Rice (Milled Equivalent)	1.63%
Starches	Roots, Other	20.53%
Starches	Rye and products	30.04%
Starches	Sorghum and products	80.33%
Starches	Sweet potatoes	29.97%
Starches	Wheat and products	1.63%
Starches	Yams	79.62%
Sugars	Honey	8.81%
Sugars	Sugar (Raw Equivalent)	1.63%
Sugars	Sugar Beet	95.88%
Sugars	Sugar cane	67.54%
Sugars	Sugar, non-centrifugal	88.00%
Sugars	Sweeteners, other	4.05%
Tobacco	Tobacco	1.63%

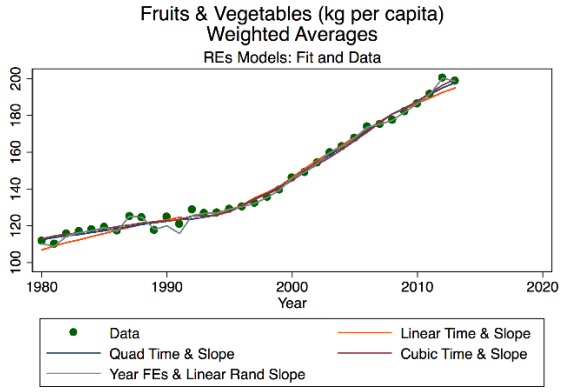
**All elements with missingness equal to 1.63% are missing data for only Ethiopia, 1980-92, and Oman, 1980-89, when all data are missing; the impacts of missing data for these two countries are explored in a sensitivity analysis, described in Chapter 3*

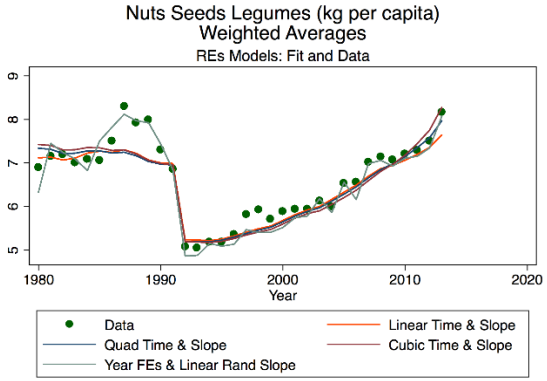
Appendix D: Model fit graphs, model output, and sensitivity analyses (Aim 1)

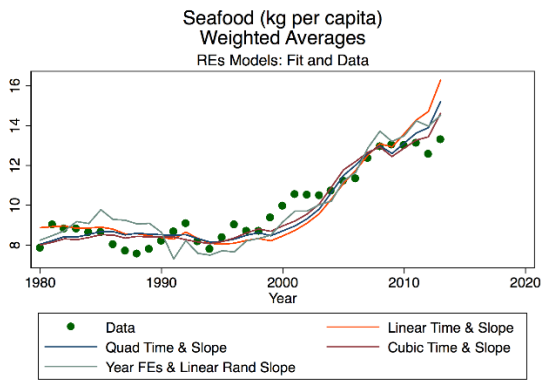
Model fit graphs

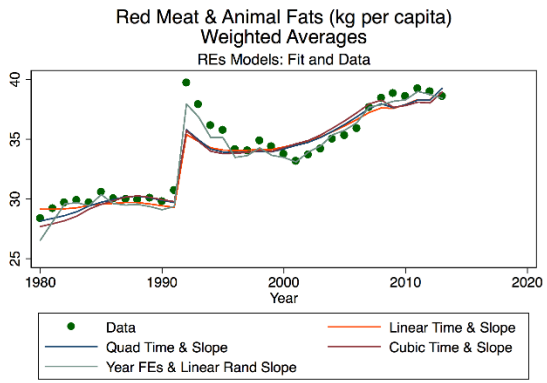


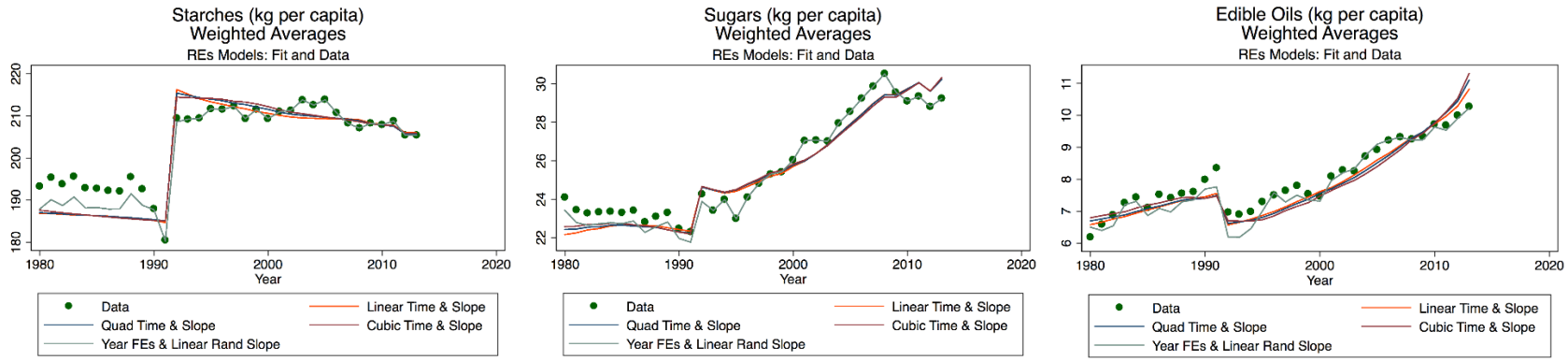












**All models include country random intercepts and random slopes, which clearly outperformed model specifications without these terms. Differences between these models are the fixed and random effects on time.*

**Linear/quad/cubic time & slope = linear, quadratic, or cubic year term and corresponding year term for country random slope; year FEs & linear rand slope = year fixed effects and linear year term for country random slope.*

Model output

Main model – full output

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.0989 *(.477)*	-0.118 *(.133)*	19.79** *(.003)*	0.107 *(.171)*	-0.137 *(.436)*	0.00831 *(.865)*	-6.277 *(.133)*	-2.401 *(.115)*	-0.070 *(.296)*
Treatment*year	0.0605* *(.054)*	0.0370* *(.050)*	-1.276 *(0.367)*	-0.0174 *(.151)*	0.0316 *(.367)*	0.00147 *(.875)*	-0.120 *(.904)*	0.250 *(.176)*	0.0053 *(.730)*
GDPpc (2005 Int $) (log)	0.449** *(.004)*	0.496*** *(<.001)*	7.571 *(.218)*	0.313 *(.060)*	0.826*** *(<.001)*	0.184* *(.020)*	5.308 *(.464)*	6.133** *(.003)*	0.150 *(.243)*
Urbanization rate (%)	-0.0166* *(.024)*	0.0141 *(.160)*	1.993** *(.004)*	-0.0046 *(.491)*	0.00607 *(.637)*	0.00401 *(.533)*	0.616 *(0.189)*	0.019 *(.879)*	0.011 *(.052)*
FLFP rate (%)	-0.0101 *(.099)*	-0.00946 *(.202)*	-1.029 *(.069)*	-0.0011 *(.804)*	-0.0360* *(.016)*	0.00252 *(.553)*	0.298 *(0.371)*	-0.133 *(.088)*	-0.0115 *(.102)*
FCTC ratification^	-0.204* *(.032)*								
Muslim population (%)^^		-0.0253*** *(<.001)*							
Year^3	-9.72x10^{-6} *(.251)*				-1.46x10^{-6} *(.875)*				
1980		(ref)	(ref)	(ref)		(ref)	(ref)	(ref)	(ref)
1981		-0.032 *(.272)*	-1.925 *(.481)*	0.179 *(.135)*		0.057 *(.058)*	1.114 *(.436)*	-0.672 *(.148)*	-0.00033 *(.995)*
1982		0.053 *(.560)*	3.214 *(.434)*	0.177* *(.014)*		0.109* *(.020)*	-1.218 *(.722)*	-0.896 *(.250)*	0.037 *(.528)*
1983		0.084 *(.379)*	4.902 *(.376)*	0.168 *(.071)*		0.110* *(.023)*	-0.122 *(.973)*	-0.826 *(.488)*	0.150*** *(.001)*
1984		0.093 *(.281)*	5.555 *(.422)*	0.135 *(.086)*		0.096 *(.079)*	-3.811 *(.299)*	-0.854 *(.331)*	0.175** *(.002)*
1985		0.018 *(.819)*	7.093 *(.306)*	0.244 *(.106)*		0.124 *(.074)*	-4.707 *(.213)*	-0.892 *(.266)*	0.126 *(.079)*

1986		0.056 *(.535)*	4.641 *(.557)*	0.306 *(.096)*		0.097 *(.145)*	-6.085 *(.172)*	-0.703 *(.456)*	0.173* *(.025)*
1987		0.049 *(.680)*	12.67 *(.178)*	0.354 *(.057)*		0.091 *(.210)*	-7.034 *(.115)*	-1.236 *(.205)*	0.171* *(.037)*
1988		0.061 *(.633)*	11.76 *(.231)*	0.364* *(.048)*		0.094 *(.248)*	-4.439 *(.389)*	-0.875 *(.460)*	0.230** *(.009)*
1989		0.085 *(.490)*	5.049 *(.648)*	0.394* *(.030)*		0.092 *(.250)*	-8.041 *(.164)*	-0.485 *(.728)*	0.259** *(.005)*
1990		0.127 *(.341)*	7.066 *(.542)*	0.357 *(.056)*		0.088 *(0.268)*	-9.913 *(0.133)*	-1.210 *(.422)*	0.329*** *(.001)*
1991		0.098 *(.507)*	2.801 *(.828)*	0.293 *(.085)*		0.101 *(.221)*	-18.06* *(.011)*	-1.273 *(.388)*	0.352** *(.002)*
1992		0.208 *(.203)*	15.45 *(.272)*	0.254 *(.125)*		0.184* *(.039)*	-24.04* *(.010)*	-1.545 *(.377)*	0.294** *(.006)*
1993		0.229 *(.167)*	16.26 *(.172)*	0.277 *(.112)*		0.168 *(.065)*	-23.33** *(.009)*	-1.787 *(.312)*	0.308* *(.015)*
1994		0.322 *(0.068)*	16.25 *(0.213)*	0.352* *(0.042)*		0.132 *(0.141)*	-23.07* *(0.016)*	-0.989 *(.648)*	0.366** *(.008)*
1995		0.267 *(.136)*	17.73 *(.200)*	0.353 *(.066)*		0.135 *(.135)*	-20.88* *(.031)*	-2.012 *(.333)*	0.458*** *(.001)*
1996		0.235 *(.195)*	17.62 *(.208)*	0.368 *(.056)*		0.086 *(.337)*	-21.12* *(.023)*	-0.999 *(.612)*	0.547*** *(<.001)*
1997		0.250 *(.176)*	17.45 *(.159)*	0.435* *(.024)*		0.085 *(.367)*	-20.10 *(.032)*	-0.362 *(.861)*	0.513*** *(<.001)*
1998		0.262 *(.153)*	19.61 *(.132)*	0.429* *(.030)*		0.100 *(.296)*	-23.14* *(.014)*	-0.038 *(.986)*	0.544*** *(<.001)*
1999		0.189 *(.395)*	21.99 *(.099)*	0.439* *(.041)*		0.078 *(.417)*	-20.82* *(.034)*	0.087 *(.972)*	0.529*** *(<.001)*
2000		0.228 *(.284)*	26.19 *(.062)*	0.458* *(.041)*		0.064 *(.526)*	-22.83* *(.023)*	0.515 *(.836)*	0.527*** *(<.001)*
2001		0.192 *(.416)*	26.98 *(.070)*	0.496* *(.032)*		0.043 *(.678)*	-20.97* *(.041)*	1.432 *(.577)*	0.618*** *(<.001)*
2002		0.176 *(.475)*	30.18 *(.054)*	0.507* *(.029)*		0.059 *(.574)*	-20.52 *(.054)*	1.185 *(.645)*	0.646*** *(<.001)*

2003		0.128 *(.622)*	34.65* *(.035)*	0.583* *(.015)*		0.063 *(.552)*	-18.17 *(.090)*	0.759 *(.772)*	0.655*** *(<.001)*
2004		0.213 *(.416)*	36.58* *(.031)*	0.527 *(.037)*		0.077 *(.469)*	-19.59 *(.069)*	1.261 *(.614)*	0.698*** *(<.001)*
2005		0.219 *(.424)*	40.03* *(.029)*	0.637* *(.012)*		0.074 *(.488)*	-18.56 *(.102)*	1.428 *(.569)*	0.727*** *(<.001)*
2006		0.172 *(.542)*	45.05* *(.023)*	0.574* *(.021)*		0.077 *(.474)*	-21.95 *(.053)*	1.669 *(.553)*	0.737*** *(<.001)*
2007		0.245 *(.382)*	45.53* *(.035)*	0.693* *(.015)*		0.097 *(.382)*	-24.79* *(.038)*	1.832 *(.533)*	0.737*** *(<.001)*
2008		0.192 *(.503)*	46.81* *(.031)*	0.703* *(.015)*		0.091 *(.434)*	-26.04* *(.031)*	2.116 *(.471)*	0.719*** *(<.001)*
2009		0.153 *(.606)*	51.34* *(.023)*	0.697* *(.015)*		0.099 *(.403)*	-24.80* *(.047)*	1.173 *(.678)*	0.723*** *(<.001)*
2010		0.114 *(.713)*	55.73* *(.012)*	0.730* *(.016)*		0.094 *(.423)*	-25.38* *(.047)*	0.412 *(.888)*	0.757*** *(<.001)*
2011		0.108 *(.731)*	61.24** *(.010)*	0.741* *(.014)*		0.102 *(.394)*	-24.88 *(.063)*	0.352 *(.902)*	0.739*** *(<.001)*
2012		0.068 *(.838)*	70.52** *(.006)*	0.772** *(.010*		0.097 *(.427)*	-27.17 *(.056)*	0.189 *(.951)*	0.762*** *(<.001)*
2013		0.045 *(.893)*	69.88** *(.009)*	0.853** *(.006)*		0.065 *(.610)*	-27.68 *(.062)*	-0.002 *(.999)*	0.760*** *(<.001)*
Constant	4.759*** *(<.001)*	-1.088 *(.337)*	7.268 *(.883)*	-1.413 *(.265)*	-3.845* *(.022)*	1.437* *(.049)*	142.4* *(.020)*	-18.94 *(.163)*	0.0659 *(.950)*
Random effects									
var(intercept) **SE**	0.944 (.199)	1.659 (.530)	6917 (1656)	3.070 (1.58)	2.95 (.747)	0.396 (.073)	5228 (1123)	87.9 (19.3)	8.46×10^{-4} (1.93×10^{-4})
var(slope) **SE**	7.83×10^{-10} (2.8×10^{-10})	0.003 (.0012)	20.16 (5.35)	.0021 (.0013)	4.38×10^{-10} (9.97×10^{-11})	2.55×10^{-4} (5.61×10^{-5})	3.67 (.828)	0.185 (.0367)	0.953 (.186)
cov(intercept, slope) **SE**	-1.3×10^{-5} (4.95×10^{-6})	-0.030 (.013)	-255.96 (87.76)	-0.0713 (.0449)	-1.13×10^{-5} 6.86×10^{-6}	-0.0058 (.0015)	-93.4 (21.9)	-2.06 (.632)	-.0251 (.0061)
var(residual) **SE**	0.215 (.046)	0.071 (.014)	437.21 (95.74)	.0764 (.0158)	0.162 (.0454)	0.0177 (.0027)	184.2 (28.2)	12.29 (2.31)	0.0519 (.0107)

**p<=0.05; **p<=0.01; ***p<=0.001; ^Tobacco model only; ^^Alcohol model only*

Sensitivity analyses

(Output displayed for treatment variables only)

I. Analysis period restricted to 1993-2011

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.0275 *(.860)*	0.00973 *(.863)*	14.29* *(.014)*	-0.0047 *(.945)*	0.0453 *(.736)*	0.0327 *(.363)*	-3.610 *(.301)*	-1.437 *(.224)*	0.0307 *(.658)*
Treatment*year	0.0601 *(.085)*	0.0300 *(.176)*	-0.361 *(.874)*	-0.0194 *(.292)*	0.0063 *(.832)*	0.0088 *(.444)*	-0.888 *(.427)*	-0.120 *(.628)*	0.0069 *(.670)*

II. Lagged treatment variables

One-year lags

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.173 *(.226)*	-0.0909 *(.190)*	20.05** *(.009)*	0.0701 *(.328)*	-0.0982 *(.494)*	0.0202 *(.639)*	-6.263 *(.154)*	-2.735* *(.038)*	-0.0497 *(.421)*
Treatment*year	0.0521 *(.072)*	0.0390* *(.039)*	-1.910 *(.158)*	-0.0104 *(.389)*	0.0343 *(.367)*	0.0015 *(.878)*	0.353 *(.722)*	0.349 *(.079)*	0.0074 *(.602)*

Two-year lags

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.249 *(.109)*	-0.108 *(.061)*	17.30* *(.017)*	0.0254 *(.659)*	-0.0322 *(.739)*	0.0197 *(.594)*	-6.756 *(.125)*	-2.364* *(.044)*	-0.0167 *(.807)*
Treatment*year	0.0385 *(.153)*	0.0407* *(.026)*	-2.602 *(.074)*	-0.0070 *(.594)*	0.0383 *(.322)*	0.0006 *(.950)*	0.868 *(.383)*	0.435* *(.048)*	0.0087 *(.491)*

III. GDP per capita excluded as covariate

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.131 *(.318)*	-0.115 *(.181)*	19.80** *(.003)*	0.111 *(.151)*	-0.0894 *(.604)*	0.00825 *(.865)*	-6.233 *(.132)*	-2.358 *(.148)*	-0.0672 *(.328)*
Treatment*year	0.0554 *(.080)*	0.0386* *(.046)*	-1.324 *(.347)*	-0.0180 *(.152)*	0.0257 *(.486)*	-0.000394 *(.967)*	-0.112 *(.912)*	0.217 *(.269)*	0.00471 *(.752)*

IV. Selected countries excluded from unexposed group (North Korea, Iraq, Afghanistan, Ethiopia, Sudan)

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.100 *(.469)*	-0.133 *(.095)*	20.59** *(.003)*	0.113 *(.142)*	-0.138 *(.432)*	0.00986 *(.838)*	-6.252 *(.136)*	-2.341 *(.126)*	-0.0784 *(.244)*
Treatment*year	0.0635* *(.048)*	0.0381 *(.052)*	-1.554 *(.329)*	-0.0198 *(.143)*	0.0252 *(.468)*	-0.000245 *(.979)*	0.0160 *(.988)*	0.314 *(.106)*	0.00974 *(.543)*

V. Stratified by income group

High income

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.0882 *(.786)*	0.556* *(.048)*	0.187 *(.976)*	0.0193 *(.886)*	-0.0531 *(.725)*	-0.00831 *(.881)*	-15.26 *(.109)*	5.164 *(.181)*	0.00235 *(.976)*
Treatment*year	-0.0266 *(.504)*	0.0665 *(.066)*	-0.101 *(.949)*	0.00381 *(.860)*	-0.0430 *(.054)*	0.0226 *(.123)*	3.303* *(.018)*	-0.170 *(.687)*	0.00335 *(.836)*

Upper-middle income

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	0.207 *(.305)*	-0.298** *(.003)*	24.14 *(.103)*	0.00411 *(.967)*	-0.148 *(.384)*	0.0703 *(.289)*	-12.51** *(.004)*	-2.473 *(.182)*	0.00296 *(.972)*
Treatment*year	0.0223 *(.111)*	0.0142 *(.606)*	0.979 *(.864)*	-0.00480 *(.771)*	0.0663 *(.119)*	0.00209 *(.845)*	-0.308 *(.794)*	0.606* *(.039)*	0.000123 *(.989)*

Low- and lower-middle income

Variable	Tobacco (log)	Alcohol (log)	Fruits & Vegetables	Nuts, Seeds, & Legumes (log)	Seafood (log)	Red Meats & Animal Fats (log)	Starches	Sugars	Edible Oils (log)
Treatment	-0.0327 *(.886)*	-0.126* *(.042)*	14.41 *(.160)*	0.207* *(.018)*	-0.167 *(.672)*	0.0287 *(.704)*	6.296 *(.337)*	-4.284** *(.010)*	-0.299* *(.017)*
Treatment*year	0.118 *(.087)*	0.0564 *(.075)*	0.494 *(.824)*	-0.00718 *(.806)*	0.0558 *(.400)*	-0.0194 *(.262)*	0.281 *(.869)*	0.0558 *(.831)*	0.0403 *(.137)*

Appendix E: Definitions of product categories used to generate outcomes (Aim 2)

Outcome	Data elements	Definition (from Euromonitor International)*
Minimally processed foods (total sales)	Eggs	Includes all fresh poultry eggs, egg albumen (egg whites) as well as liquid or dry hen eggs.
	Fish and seafood	This is the aggregation of fish, crustaceans, mollusks and cephalopods. Includes: fresh raw (chilled and frozen) packaged and unpackaged unprocessed fish and seafood. Chilled and frozen fish and seafood can be cleaned, gutted, peeled/trimmed/filleted/cut to a different extent, but not cooked and no sauces, herbs or condiments can be added. Excludes: All packaged/processed fish and seafood products typically sold via the self-service counters in retail outlets.
	Fruits	This is the aggregation of fresh apples, bananas, cherries, cranberries & blueberries, grapefruit & pomelo, grapes, kiwi fruit, lemons & limes, oranges, tangerines & mandarins, peaches & nectarines, pears &quinces, plums & sloes, pineapples, strawberries and other fruits, whether sold packaged or unpackaged. Dried fruits and fruit snacks whether sold packaged or by weight are included. Large fruit, such as watermelons and melons, cut and packed by retailers at their premises are also included. All other packaged, processed fruit products such as fresh cut fruits marketed as fresh fruit snacks and salads, cut frozen fruits and berries, jams & preserves, canned/preserved fruits, fruit juices and juice drinks are excluded.
	Meat	This is the aggregation of beef & veal, lamb, mutton & goat, pork, poultry and other meat. Only includes fresh uncooked and unprocessed meat whether packaged or unpackaged. All industrially packaged/processed meat products typically sold via the self-service or delicatessen counters in retail outlets are excluded. This category does not cover offal, animal fat, skins and hides.
	Nuts	This includes unpackaged nuts used mainly as dessert or table nuts and is the aggregation of almonds, walnuts, pistachio, peanuts (or groundnuts) and other nuts. Note: nuts used mainly for flavoring beverages and the extraction of oil or fat are excluded, as are chewing/stimulant nuts: areca/betel nuts, kola nuts, illipe nuts, karate/shea nuts, tung nuts, oil palm nuts, etc. All packaged, processed nuts such as roasted nuts and raw but de-shelled nuts are excluded.
	Pulses	This category is limited to leguminous crops harvested only for dry grains, excluding crops harvested green for food (green peas, green bean, string beans, etc.), which are considered to be vegetables. Also exclude those used mainly for the extraction of oil (e.g., soybeans) and those leguminous crops such as clover and alfalfa, which seeds are almost used exclusively for sowing purpose. This is the aggregation of dry beans, peas and other pulses.
	Starchy roots	This is the aggregation of unpackaged and unprocessed potatoes, cassava, sweet potatoes and other roots. Starchy root-based products such as chips, crisps as well as flour are excluded.

	Vegetables	This is the aggregation of tomatoes, onions and other vegetables. Only include fresh uncooked and unprocessed vegetables (packaged and unpackaged) and unpackaged processed vegetables, eg. salted vegetables sold from open market. All packaged/processed vegetable products are excluded.
Processed culinary ingredients (total sales)	Butter and margarine	This is the aggregation of butter and margarine.
	Drinking milk products	This is the aggregation of fresh/pasteurised milk, long-life/UHT milk, goat milk, flavoured milk drinks, non-dairy milk alternatives, powder milk and flavoured powder milk drinks.
	Oils and fats	This is the aggregation of olive oil, vegetable and seed oil, cooking fats, butter, margarine, and spreadable oils and fats.
	Other dairy	This is the aggregation of chilled and shelf stable desserts, chilled snacks, coffee whiteners, condensed/evaporated milk, cream, and fromage frais and quark.
	Processed fruits and vegetables	This is the aggregation of shelf stable fruit and vegetables and frozen fruit and vegetables.
	Rice, pasta, and noodles	This is the aggregation of rice, noodles and pasta. Includes: Pre-packaged noodles. Excludes: Any noodles, pasta or rice bought loose, bulk and/or unpackaged. Excludes: Any noodle-based ready meals, which would be tracked under ready meals.
	Sugar and sweeteners	All raw sugar products and natural sweeteners, whether sold packaged or unpackaged, including yellow/brown sugar, fructose, maltose, maple sugar, molasses, corn syrup, glucose, table sugar (also known as granulated refined white sugar), icing sugar, castor sugar, etc. Honey is included here. Note: Artificial sweeteners such as aspartame and acesulfame-K are excluded. Also exclude sugar alcohol such as erythritol, xylitol and mannitol, which are commonly used for replacing sucrose in foodstuffs and often used in combination with high intensity artificial sweeteners.
Ultra-processed products (total sales)	Baked goods	This is the aggregation of bread, pastries and cakes. Note: Baked goods from in-store bakeries are classified under unpackaged/artisanal, not packaged/industrial. While they may be finished on-site, they are often prepared, then frozen or par-baked, at other locations. Such production models are very important for supermarket in-store bakeries, which have in the past been used to drive traffic and fill stores with appetizing aromas, but for which the labor resources required to run a full-service scratch bakery are not always available
	Breakfast cereals	This is the aggregation of ready-to-eat (RTE) and hot cereals.
	Cheese	This is the aggregation of processed and unprocessed cheese.
	Chocolate confectionary	This is the aggregation of tablets, countlines, bagged selflines/softlines, boxed assortments, seasonal chocolate, chocolate with toys, alfajores and other chocolate confectionery. Note that chocolate overtly positioned for baking/cooking purposes is excluded from Euromonitor International's confectionery coverage.
	Ice cream and frozen desserts	This is the aggregation of all sales of ice cream and frozen desserts
	Processed meat and seafood	This is the aggregation of processed meat, processed seafood and meat substitutes.

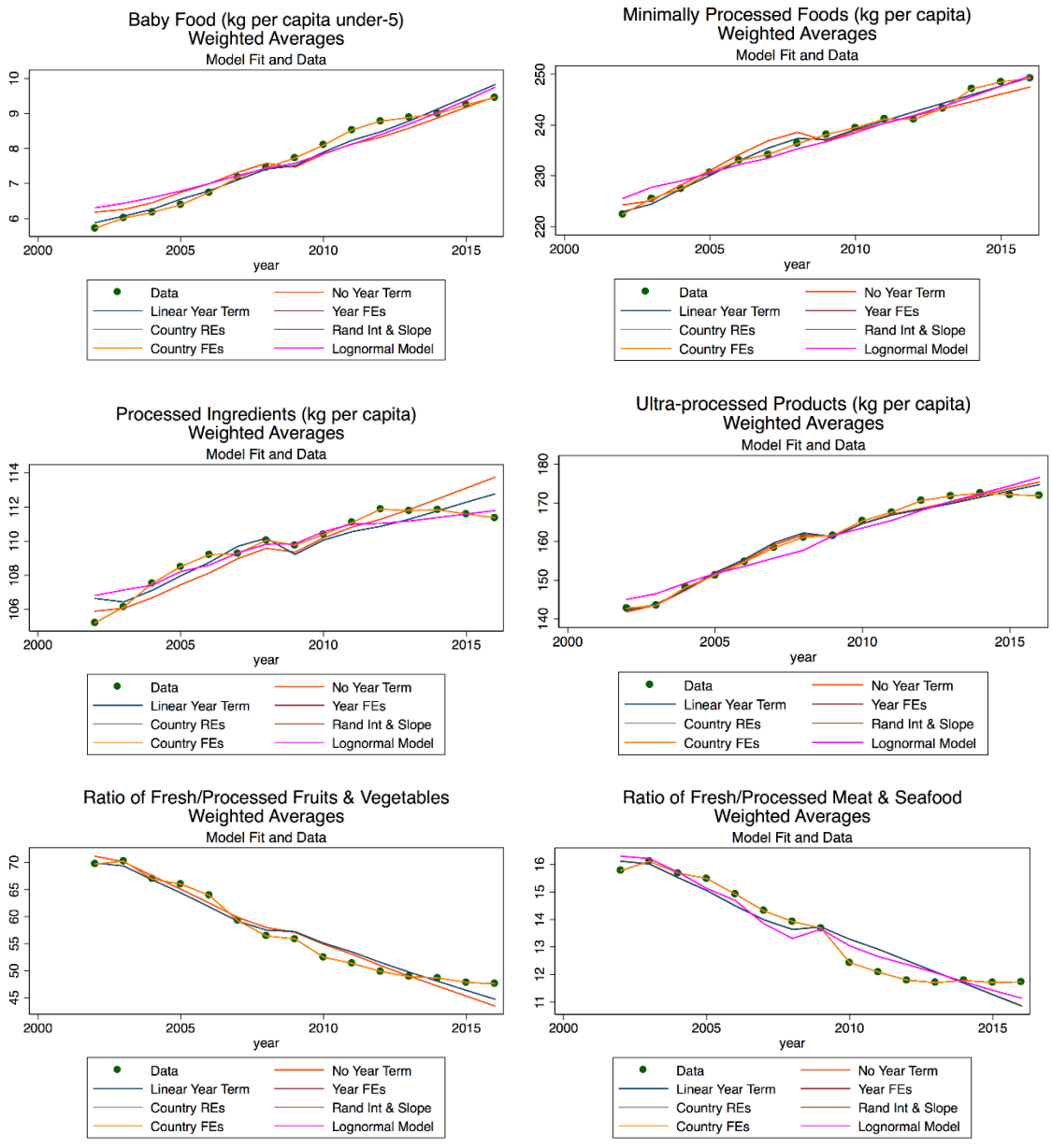
	Ready meals	This is the aggregation of canned/preserved, frozen, dried, chilled ready meals, dinner mixes, frozen pizza, chilled pizza and prepared salads. Note: Ready meals are products that have had recipe "skills" added to them by the manufacturer, resulting in a high degree of readiness, completion and convenience. Ready meals are generally accepted to be complete meals that require few or no extra ingredients, however, in the case of canned/preserved ready meals, the term also encompasses meal "centers'; for dinner mixes, the term encompasses part meals. Some ready meals may require cooking; others may simply need reheating, prior to serving.
	Sauces, dressings, and condiments	This is the aggregation of tomato pastes and purees, bouillon/stock cubes, herbs and spices, monosodium glutamate (MSG), table sauces, soy based sauces, pasta sauces, wet/cooking sauces, dry sauces/powder mixes, ketchup, mayonnaise, mustard, salad dressings, vinaigrettes, dips, pickled products, and other sauces, dressings and condiments.
	Savory snacks	This is the aggregation of fruit snacks, chips/crisps, extruded snacks, tortilla/corn chips, popcorn, pretzels, nuts and other sweet and savory snacks
	Soup	This is the aggregation of canned/preserved, dehydrated, instant, chilled, UHT and frozen soup.
	Spreads	This is the aggregation of jams and preserves, honey, chocolate spreads, nut based spreads, and yeast based spreads
	Sugar confectionary	This is the aggregation of mints, boiled sweets, pastilles, gums, jellies and chews, toffees, caramels, nougat, medicated confectionery, lollipops, liquorice and other sugar confectionery.
	Sweet biscuits, snack bars, and fruit snacks	This is the aggregation of biscuits and snack bars.
	Yogurt and sour milk products	This is the aggregation of yoghurt and sour milk drinks.
	Carbonates	Sweetened, non-alcoholic drinks containing carbon dioxide are included here. All carbonated products containing fruit juice ("sparkling juices") are included here, unless they are tea-based (these are included in carbonated RTD tea) or carbonated Energy drinks, which are included in Energy Drinks. Carbonated bottled water is also excluded. Carbonates are an aggregation of cola carbonates and non-cola carbonates, whether regular or low calorie. Euromonitor International includes both naturally and artificially-sweetened carbonates.
	Concentrates	This is the aggregation of liquid concentrates and powder concentrates.
	Juice	This category covers all still packaged juice obtained from fruits or vegetables by mechanical processes, reconstituted or fresh, often including pulp or fruit/vegetable puree. All unpackaged juices are excluded. Only still drinks are included here. Carbonated varieties are included non-cola carbonates. Juice-flavoured milk drinks and fruit shakes which are primarily milk are excluded–these are instead tracked in Packaged Foods Dairy. However, if the juice component is greater, the product is to be excluded from Packaged Foods Dairy coverage and tracked under the relevant category (based on % juice content) within Soft Drinks juice. This sector is the aggregation of

		100% juice, nectars (25-99% juice content), juice drinks (up to 24% juice content), and fruit-flavored drinks (no juice content).
	Ready-to-drink coffee	Includes packaged ready-to-drink coffee, consumed either hot or cold, made using a base of either brewed coffee or coffee extract. Excludes all coffee flavored milk drinks that primarily target children, or where coffee is one of a number of flavors within the brand range. Leading brands in off-trade volume include Georgia, Nescafé and Suntory Boss.
	Ready-to-drink tea	This category includes all packaged products based on brewed tea or tea extract. May be sweetened or unsweetened, carbonated or still, with a wide variety of different flavorings. May contain juice.
	Sports and energy drinks	This category is the aggregation of sports and energy drinks.
Baby food (total sales)	Baby food	This is the aggregation of milk formula, prepared, dried and other baby food.
Fresh/processed meat and seafood (sales ratio)	Meat	*See above* – Minimally processed foods: Meat
	Fish and seafood	*See above* – Minimally processed foods: Fish and seafood
	Processed meat and seafood	*See above* – Ultra-processed products: Processed meat and seafood
Fresh/processed fruits and vegetables (sales ratio)	Fruits	*See above* – Minimally processed foods: Fruits
	Vegetables	*See above* – Minimally processed foods: Vegetables
	Processed fruits and vegetables	*See above* – Processed culinary ingredients: Processed fruits and vegetables

**Definitions as provided in 2017; Available from: http://www.portal.euromonitor.com/help/definitions (subscription required)*

Appendix F: Model fit graphs, model output, and sensitivity analyses (Aim 2)

Model fit graphs



**FEs = fixed effects; REs = random intercepts; Rand Int & Slope = random intercept and random slope*
**Model fits for all models with year fixed effects (with addition of: country random intercept, country random intercept and random slope, or country fixed effects) are shown but are indistinguishable.*
**Lognormal model would not converge for Fresh/Processed Fruits & Vegetables outcome*

Model output

Main model – full output

Variable	Minimally processed foods	Processed culinary ingredients	Ultra-processed products	Baby Food	Fresh/ Processed Meat & Seafood	Fresh/ Processed Fruits & Vegetables
Treatment	-1.226 *(.218)*	-0.661 *(.157)*	-2.462* *(.029)*	-0.265 *(.150)*	0.674* *(.035)*	3.484** *(.004)*
Treatment*year	-0.104 *(.764)*	0.864*** *(<.001)*	1.396*** *(<.001)*	0.191** *(.002)*	-0.234* *(.019)*	-1.682*** *(<.001)*
GDPpc (log) (2005 Int $)	1.050 *(.858)*	29.63*** *(<.001)*	120.2*** *(<.001)*	6.531*** *(<.001)*	-6.118*** *(<.001)*	-13.34 *(.055)*
Urbanization rate (%)	1.909*** *(<.001)*	-0.359 *(.131)*	-1.761*** *(<.001)*	-0.072* *(.015)*	0.226* *(.010)*	-0.916* *(.050)*
FLFP rate (%)	-0.0562 *(.756)*	-0.111 *(.201)*	1.16*** *(<.001)*	0.005 *(.848)*	0.102* *(.049)*	-0.731*** *(.001)*
2002	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
2003	2.313* *(.024)*	0.623 *(.196)*	-0.650 *(.571)*	0.222 *(.234)*	0.324 *(.318)*	1.244 *(.343)*
2004	3.590* *(.004)*	0.855 *(.152)*	-1.065 *(.442)*	0.138 *(.502)*	-0.007 *(.985)*	-0.942 *(.582)*
2005	6.091*** *(<.001)*	0.636 *(.401)*	-3.156 *(.068)*	0.099 *(.674)*	-0.078 *(.862)*	-0.509 *(.819)*
2006	7.849*** *(<.001)*	0.003 *(.997)*	-5.029* *(.018)*	0.174 *(.521)*	-0.476 *(.370)*	-1.321 *(.638)*
2007	8.433*** *(<.001)*	-1.245 *(.274)*	-6.858** *(.007)*	0.317 *(.311)*	-0.934 *(.136)*	-4.441 *(.194)*
2008	9.951*** *(<.001)*	-1.417 *(.281)*	-7.678** *(.009)*	0.385 *(.277)*	-1.184 *(.099)*	-5.907 *(.141)*
2009	11.28*** *(<.001)*	-1.503 *(.301)*	-6.112 *(.058)*	0.702 *(.078)*	-1.583* *(.049)*	-5.660 *(.216)*
2010	12.04*** *(<.001)*	-2.101 *(.202)*	-6.935 *(.057)*	0.795 *(.074)*	-2.638** *(.004)*	-7.347 *(.157)*
2011	13.13*** *(.001)*	-2.400 *(.190)*	-8.182* *(.043)*	1.008* *(.041)*	-2.825** *(.005)*	-7.005 *(.228)*
2012	12.60** *(.002)*	-2.615 *(.196)*	-8.436 *(.059)*	1.045 *(.055)*	-2.985** *(.007)*	-7.181 *(.265)*
2013	14.27** *(.002)*	-3.755 *(.089)*	-10.55* *(.030)*	0.917 *(.124)*	-2.900* *(.017)*	-6.699 *(.343)*
2014	17.56*** *(<.001)*	-4.797* *(.045)*	-13.25* *(.012)*	0.792 *(.222)*	-2.621* *(.047)*	-5.417 *(.481)*
2015	18.40*** *(<.001)*	-6.138* *(.018)*	-17.07** *(.003*	0.806 *(.250)*	-2.487 *(.081)*	-4.773 *(.566)*
2016	18.67** *(.001)*	-7.447** *(.007)*	-20.70*** *(.001)*	0.765 *(.310)*	-2.261 *(.140)*	-3.521 *(.694)*
Intercept	70.09 *(.190)*	-134.3*** *(<.001)*	-883.2*** *(<.001)*	-49.06*** *(<.001)*	49.83*** *(<.001)*	297.3*** *(<.001)*
Random effects						
var(intercept) **SE**	3,008 703	1,088 249	6,126 1,456	4.81 1.21	130.4 31.1	5,564 1301

var(slope)	4.91	0.95	4.36	0.09	0.37	14.0
SE	1.20	0.22	1.04	0.02	0.09	3.16
cov(int., slope)	67.3	-1.54	29.5	0.19	-5.94	-239
SE	22.2	5.26	26.8	0.12	1.54	59.6
var(residual)	18.1	3.96	23.2	0.65	1.91	26.9
SE	1.13	0.25	1.45	0.04	0.12	1.68

*p<=0.05; **p<=0.01; ***p<=0.001

Sensitivity analyses

(Output displayed for treatment variables only)

I. Modelled data excluded

Variable	Minimally processed foods	Fresh/ Processed Meat & Seafood	Fresh/ Processed Fruits & Vegetables
Treatment	-1.351 *(.245)*	0.901** *(.010)*	2.523 *(.123)*
Treatment*year	0.0300 *(.940)*	-0.509*** *(<.001))*	-1.028* *(.028)*

II. Products with high missingness excluded (ready-to-drink coffee, ready-to-drink tea)

Variable	Ultra-processed products
Treatment	-2.375* *(.034)*
Treatment*year	1.233** *(.002)*

III. Venezuela excluded from unexposed group

Variable	Minimally processed foods	Processed culinary ingredients	Ultra-processed products	Baby Food	Fresh/ Processed Meat & Seafood	Fresh/ Processed Fruits & Vegetables
Treatment	-1.458* *(.014)*	-0.396 *(.068)*	-2.515*** *(<.001)*	-0.157 *(.108)*	0.594*** *(.001)*	3.161*** *(<.001)*
Treatment*year	0.00779 *(.970)*	0.692*** *(<.001)*	1.143*** *(<.001)*	0.135*** *(<.001)*	-0.176*** *(.001)*	-1.435*** *(<.001)*

Appendix G: Data abstraction & quality assessment tool (Aim 3)

Study Details: Data Abstraction

1. What is the study design (e.g., natural experimental, cross-sectional analysis, longitudinal analysis)?
2. What countr(ies) are included?
3. What year(s) are covered?
4. What is the exposure of interest?
    a. What are the data source(s) for the exposure variable(s)?
    b. What indicator(s) are used for the exposure variable(s)?
5. What are the outcome(s) of interest?
    a. What are the data source(s) for the outcome variable(s)?
    b. At what level were data for the outcome variable(s) collected (e.g., individual, household, country)?
    c. What indicator(s) are used for the outcome variable(s)?
6. What type(s) of statistical test(s) and/or model(s) were used?

Assessment of Study Quality

I. Study Design
    a. Is the aspect of trade and/or investment (i.e., policy, liberalization, flows) that is being investigated clearly articulated in the research question(s)?
        i. Yes
        ii. No
    b. Are trade and investment treated jointly or separately in the research question(s)?
        i. Only trade considered
        ii. Only investment considered
        iii. Both considered, jointly
        iv. Both considered, separately
    c. Is the theoretical link between trade/investment and the outcome(s) described and supported with existing literature and/or a conceptual model?
        i. Yes, supported by literature only
        ii. Yes, supported by conceptual model
        iii. No

II. Indicators
    a. Do trade and/or investment indicator(s) align with the aspect of trade/investment (i.e., policy, liberalization, flows) examined in the study?
        i. Yes
        ii. No

b. If an index (e.g., globalization index) or broader macroeconomic policy (e.g., structural adjustment program) is used as the explanatory variable, is an attempt made to disaggregate trade/investment from other aspects of the index or policy?
    i. Yes
    ii. No
    iii. N/A
c. If multiple trade/investment agreements are compared, is any adjustment made for variations in the depth or scope of agreements?
    i. Yes
    ii. No
    iii. N/A
d. Do trade and/or investment indicator(s) reflect the whole economy or are they specific to one or more sectors most relevant to the outcome(s) examined?
    i. Economy-wide
    ii. Sector-specific

III. Analysis

a. What confounding, mediating, and moderating variables have been examined?
    i. Confounders:
    ii. Mediators:
    iii. Moderators:
b. Did the authors report testing alternative statistical models and were any criteria provided for model selection?
    i. Yes
    ii. No
c. Is the potential for endogeneity or reverse causality mentioned and is there any description of measures taken to account for this?
    i. Yes, mentioned and addressed. Describe:
    ii. Yes, mentioned, but no consideration in design or analysis
    iii. Not mentioned
d. If longitudinal data were used, was autocorrelation accounted for in statistical models?
    i. Yes
    ii. No
    iii. N/A
e. Were any sensitivity analyses described to explore the robustness of findings to alternative methodological decisions and/or model specifications?
    i. Yes
    ii. No

Appendix H: Study details of 34 quantitative studies (Aim 3)

Lead Author (Year)	Title	Countries	Years	Trade and investment indicators	NCD-related indicators
Alam (2016)	Accounting for Contribution of Trade Openness and Foreign Direct Investment in Life Expectancy: The Long-Run and Short-Run Analysis in Pakistan	Pakistan	1972-2013	(exports + imports) % of GDP, real inflows of FDI	Life expectancy at birth
Baker (2016)	Trade and investment liberalization, food systems change and highly processed food consumption: a natural experiment contrasting the soft-drink markets of Peru and Bolivia	Peru, Bolivia	1999-2013	Dummies for pre-post: 1) ratification and 2) enforcement of Peru-US FTA	FDI inflows per capita; soft drink imports per capita; soft drink (various types) sales per capita; sugar from soft drinks per capita
Barlow (2017)	Impact of the North American Free Trade Agreement on high-fructose corn syrup supply in Canada: a natural experiment using synthetic control methods	Canada; 16 OECD countries (weighted average for synthetic control)	1985-2000	Dummy for pre-post NAFTA	Supply of caloric sweeteners (kcal per capita)
Bergh (2010)	Good for Living? On the Relationship between Globalization and Life Expectancy	92 countries (28 HICs, 41 MICs, 23 LICs)	1970-2005	KOF Index (total, and disaggregated by economic/political/social); compare with CSGR Index	Life expectancy at birth (total and by sex)
Burns (2017)	Is foreign direct investment good for health in low and middle income countries? An instrumental variable approach	85 LMICs	1974-2012	FDI inflows as % of GDP (total and by primary/secondary/tertiary sector)	Life expectancy at birth; Adult mortality, per 10,000 adults
Bussmann (2009)	The Effect of Trade Openness on Women's Welfare and Work Life	134 countries	1970-2000	total trade % of GDP	Female life expectancy at birth

Lead Author (Year)	Title	Countries	Years	Trade and investment indicators	NCD-related indicators
Chaloupka (1996)	U.S. Trade Policy and Cigarette Smoking in Asia	10 Asian countries (4 where Section 301 opened cigarette market & 6 with more protected cigarette markets)	1970-1991	Dummy for pre-post Section 301 agreement (fraction to indicate portion of year in year agreement reached)	Per capita cigarette consumption; market share of U.S. cigarettes
Costa-Font (2014)	'Globesity'? The Effects of Globalization on Obesity and Caloric Intake	26 countries (mostly high-income, few upper-middle income)	1989-2005	KOF Index (economic, political, and social, disaggregated); compare with CSGR Index	% of population obese; Average caloric intake
DeVogli (2013)	The influence of market deregulation on fast food consumption and body mass index: a cross-national time-series analysis	25 OECD countries	1999-2008	Index of Economic Freedom	Adult (over age 20) mean BMI (total and by sex)
DeVogli (2014)	Economic globalization, inequality and body mass index: a cross-national analysis of 127 countries	127 countries	1980-2008	KOF Index (economic subdomain only); (imports + exports) % of GDP & FDI % of GDP - both subcomponents of economic index but also included separately in models	Mean BMI, adults of both sexes combined
Estime (2014)	Trade as a structural driver of dietary risk factors for noncommunicable diseases in the Pacific: an analysis of household income and expenditure survey data	5 Pacific Island countries	single year between 2005-10, varies by country	imported foods as % of total in terms of 1) caloric intake and 2) expenditure	Expenditure on 'unhealthy' foods (% of total spending); 'unhealthy' foods caloric intake (% of total); National obesity rates

Lead Author (Year)	Title	Countries	Years	Trade and investment indicators	NCD-related indicators
Goryakin (2015)	The impact of economic, political and social globalization on overweight and obesity in the 56 low and middle income countries	56 LMICs	1991-2009, selected years, by country (single year for 19 countries)	KOF Index (total, and disaggregated by economic/political/social)	Dummy for above normal weight (BMI>25) (women, aged 15-49)
Herzer (2015)	The long-run effect of trade on life expectancy in the United States: An empirical note	United States	1960-2011	total trade % of GDP	Life expectancy at birth
Herzer (2012)	FDI and health in developed economies: A panel cointegration analysis	14 high-income countries	1970-2009	FDI % of GDP	Life expectancy at birth
Lee (2012)	South Korea's entry to the global food economy: shifts in consumption of food between 1998 and 2009	South Korea	1998 & 2009	"transition period when the Korean food system became open to global influences and trade" (not clearly defined indicator)	Consumption per capita and per consumer (for each of 53 food groups)
Levine (2006)	Does trade affect child health?	129 countries	1990 (or closest year available)	predicted (from gravity model) and actual total trade as % of GDP	Life expectancy at birth
Ljungvall (2013)	The freer the fatter? A panel study of the relationship between body-mass index and economic freedom	31 high-income countries	1983-2008 (6 time points)	Economic Freedom of the World Index	Adult (over age 20) mean BMI (total and by sex)
Lopez (2016)	Is trade liberalization a vector for the spread of sugar-sweetened beverages? A cross-national longitudinal analysis off 44 low- and middle-income countries	44 LMICs	2001-2014	Applied tariff (MFN) (average for HS lines 2202 & 2009)	SSB imports per capita; SSB sales per capita

Lead Author (Year)	Title	Countries	Years	Trade and investment indicators	NCD-related indicators
Martens (2010)	Is globalization healthy: a statistical indicator analysis of the impacts of globalization on health	117 countries	2007	Maastricht Globalization Index (total and by each of five domains)	Probability of dying between age 15 and 60 per 1000 population
Miljkovic (2015)	Globalisation and Obesity	79 countries	1986-2008	trade % of GDP; FDI % of GDP; globalization social index (GSI); globalization economic index (GEI) (GEI dropped from final analyses)	% of adults obese, by sex
Mukherjee (2011)	Globalization and human well-being	132 countries	1970-2007 (averages for every 5-yr period)	KOF Index (total, and disaggregated by economic/political/social)	Life expectancy at birth
Mwabu (1996)	Health effects of market-based reforms in developing countries	103 countries (51 with SAPs, 52 without)	1980-1993 (predictor variables, 1980-91; outcome, 1993)	Dummy variable for successful implementation of structural adjustment reforms; additional dummies for the sector where reforms were implemented, e.g., agriculture, health	Difference between life expectancy at birth in 1993 and 80 (chosen as ideal life expectancy)
Nandi (2014)	Associations Between Macrolevel Economic Factors and Weight Distributions in Low- and Middle-Income Countries: A Multilevel Analysis of 200 000 Adults in 40 Countries	40 LMICs	2002 or 2003, varies by country	FDI % of GDP (converted to z-scores); Mean tariff rate, 1990-99 (converted to standardized scores)	Mean BMI among adults 18-65, by sex (country-level); Categorical BMI (overweight, normal, underweight) (individual-level)
Oberlander (2016)	Globalisation and national trends in nutrition and health - a grouped fixed effects approach to inter-country heterogeneity	70 high- and middle-income countries	1980-2008	KOF index (economic and social domains, separately)	Animal proteins, free fats, sugars (all in kcal per capita per day); diabetes prevalence; mean BMI

Lead Author (Year)	Title	Countries	Years	Trade and investment indicators	NCD-related indicators
Owen (2007)	Is Trade Good for Your Health?	219 countries	1960-1995 (5-year intervals)	Trade % of GDP; black market premium; Sachs-Warner Index (dummy variable); average imports weighted by trading partners' infant mortality rate	Life expectancy at birth (by sex)
Schram (2013)	Urbanization and International Trade and Investment Policies as Determinants of Noncommunicable Diseases in Sub-Saharan Africa	48 Sub-Saharan African countries	2008	KOF Index (economic subdomain only)	Prevalence of overweight; prevalence of obesity; Proportion of deaths attributable to CVD
Schram (2015)	The role of trade and investment liberalization in the sugar-sweetened carbonated beverages market: a natural experiment contrasting Vietnam and the Philippines	Vietnam, Philippines	1999-2013	dummy for pre-post WTO accession	SSB sales per capita (off-trade); growth rate of SSB sales (domestic companies); growth rate of SSB sales (foreign companies)
Stevens (2013)	Healthy trade: The relationship between open trade and health.	Not stated but about 99 countries, based on N in model output	1970-2005 (5-yr intervals)	total trade % of GDP; dummy for U.S. FTA in force	Life expectancy at birth (by sex)
Stroup (2007)	Economic freedom, democracy, and the quality of life	104 countries	1980-2000	Economic Freedom Index	Life expectancy at birth
Stuckler (2008)	Population Causes and Consequences of Leading Chronic Diseases: A Comparative Analysis of Prevailing Explanations	56 countries	1960-2000	total FDI; total capital flows as % of GDP	CVD mortality rate (male); NCD mortality rate (male)
Stuckler (2012)	Manufacturing Epidemics: The Role of Global Producers in Increased Consumption of Unhealthy Commodities Including Processed Foods, Alcohol, and Tobacco	50 LMICs	1997-2010	FDI % of GDP	Per capita sales of several categories of ultra-processed foods (in kg), tobacco (in USD value), alcohol (in USD value)
Tausch (2016)	Is globalization really good for public health?	99 countries	1970-2010 (5-yr intervals)	"actual flows of foreign capital" from KOF Index	Life expectancy at birth

Lead Author (Year)	Title	Countries	Years	Trade and investment indicators	NCD-related indicators
Taylor (2000)	The impact of trade liberalization on tobacco consumption	42 countries	1970-1995	(imports + exports) % of GDP	Cigarette consumption per capita
Umana-Pena (2014)	Assessment of the Association of Health with the Liberalisation of Trade in Services under the World Trade Organisation	114 WTO members	1995 & 2010	Index of service sector liberalization; index of liberalization in the health and social services subsector	Life expectancy at birth; Change in life expectancy, 1995-2010; Ideal potential improvement in life expectancy, 1995-2010; Ratio of observed to ideal change in life expectancy

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Curriculum Vitae

KRYCIA COWLING

Born: April 6, 1985, London, United Kingdom

EDUCATION

Johns Hopkins University, Baltimore, MD
PhD, Health and Public Policy, specialization in Comparative Social Policy and Health, Dec. 2017

University of Washington, Seattle, WA
MPH, Global Health: Health Metrics and Evaluation, Aug. 2011

BS, Public Health (with College Honors), Minor in Norwegian, *Cum Laude,* June 2007
Studies Abroad: Quito, Ecuador, Winter 2007; Harare, Zimbabwe, Summer 2005

EXPERIENCE

World Bank, Washington, DC
Consultant – Primary Health Care Performance Initiative Dec. 2015 – Feb. 2017; Sept. 2017 –
Consultant – Health, Nutrition and Population Group May – July 2015

Johns Hopkins University, Baltimore, MD March 2014 – March 2016 (*intermittent*)
Teaching Assistant

Baltimore City Health Department, Baltimore, MD February 2014 – May 2015
Intern - Health Impact Assessment

Public Health Foundation of India, Delhi, India October 2011 – July 2013
Research Scholar
Institute for Health Metrics and Evaluation October 2011 – September 2012
Research Scientist (joint position)

Institute for Health Metrics and Evaluation, Seattle, WA September 2008 – August 2011
Post-Bachelor Fellow

Badan Pusat Statistik (Statistics Indonesia), Jakarta, Indonesia July – August 2010
Master's Practicum

Free and Clear, Inc., Seattle, WA June 2007 – July 2008
Tobacco Cessation Counselor

Zimbabwe Community Health Intervention Research Project, Harare, Zimbabwe June –
Research Intern August 2005

RESEARCH

Peer-Reviewed Publications

Veillard J, **Cowling K**, Ratcliffe H, et al. Better Measurement for Performance Improvement in Low and Middle Income Countries: The Primary Health Care Performance Initiative (PHCPI) Experience of Conceptual Framework Development and Indicator Selection. *Milbank Quarterly*. In press.

Cowling K, Lindberg R, Dannenberg AL, Neff RA, Pollack KM. Review of Health Impact Assessments Informing Agriculture, Food, and Nutrition Policies and Projects in the United States**.** *Journal of Agriculture, Food Systems, and Community Development*. 2017; 7(3).

Cowling K, Dandona R, Dandona L. Improving the estimation of the tuberculosis burden in India. *WHO Bulletin.* 2014; 92(11): 817-825.

Cowling K, Dandona R, Dandona L. Social determinants of health in India: progress and inequities across states. *International Journal for Equity in Health.* 2014; 13(88).

Gakidou E**, Cowling K,** Lozano R, Murray CJL. Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: a systematic analysis. *The Lancet*. 2010; 376: 959–974.

Other Publications

World Bank. Optimizing Investments in Preparedness and Health Systems Strengthening: Building Resilience. *Meeting Report*. Bellagio, Italy, April 26-30, 2016.

Veillard J, Iunes R, Suarez RG, **Cowling K**. "Chapter 2: Health." in *Republic of Chile: Public Expenditure Review*. World Bank: Washington, DC, 2016.

Taylor AL, Jacobson MF. Carbonating the World: The Marketing and Health Impact of Sugar Drinks in Low- and Middle-income Countries. Center for Science in the Public Interest: Washington, DC, 2016.

Cowling K. Net effects of bicycle share programs on bike safety. *American Journal of Public Health.* 2014; 104(11): e6

Birnbaum J, **Cowling K**, Foreman K, Fullman N, Gubbins P, Levin-Rector A, Makela S, Marcus J, Myerson R, Schneider M. Sceptical optimism: a new take on global health data. *The Lancet.* 2009; 374: 1730-1731.

Presentations

Cowling K. NCD risk factor trends after trade liberalization: case-control studies of countries joining the WTO and U.S. free trade agreements. Oral Presentation. Atlanta, GA: American Public Health Association Annual Meeting. November 4-8, 2017.

Cowling K. Front-of-package nutrition rating labels: Analysis of potential conflicts with World Trade Organization rules. Oral Presentation. Chicago, IL: American Public Health Association Annual Meeting. October 31-November 4, 2015.

Cowling K. Assessing equity in the distribution of bilateral development assistance for health, 1990-2010. Poster Presentation. Chicago, IL: American Public Health Association Annual Meeting. October 31-November 4, 2015.

Freeman MK, Sanman E, **Cowling K**, Ng M, Lopez A, Mokdad A, Murray CJL, Gakidou E. Concentrating risk: a systematic analysis of the global smoking epidemic. Oral Presentation. Seattle, WA: Global Health Metrics & Evaluation. June 17-19, 2013.

Johns N, **Cowling K**, Gakidou E. The Wealth (and Health) of Nations: The relationship between wealth and inequality in disease burden estimation. Oral Presentation. Seattle, WA: Global Health Metrics & Evaluation. June 17-19, 2013.

Cowling K, Dandona R, Dandona L. Better estimation of the burden of tuberculosis in India: what data are needed? Oral Presentation. Lucknow, India: India Clinical Epidemiology Network (IndiaCLEN) Annual Conference. March 2-3, 2013.

Cowling K, Dandona R, Dandona L. Measuring the burden of tuberculosis in India: what data are needed? Oral Presentation. Delhi, India: Public Health Foundation of India Research Symposium. January 7-8, 2013.

Alvarado MR, **Cowling K**, Lozano R, Gakidou E. Reduction of inequalities in child mortality through maternal education: an individual-level analysis. Oral Presentation. Seattle, WA: Global Health Metrics & Evaluation: Controversies, Innovation, Accountability, March 14-16, 2011.

Cowling K, Murray CJL, Jamison D, Lim S, Lozano R, Gakidou E. Estimating Educational Attainment. Poster Presentation. Seattle, WA: Global Health Education Consortium: Transcending Global Health Barriers, Education and Action, April 3-5, 2009.

Cowling K. Structural Adjustment Programs: Proposed versus actual effects on public health. Poster Presentation. Seattle, WA: University of Washington Undergraduate Research Symposium, May 18, 2007.

Montano M, **Cowling K**, Dorres M, Goldenkranz S. Effect of employee sense of efficacy on community interventions for HIV prevention. Poster Presentation. Toronto, Canada: International AIDS Conference, August 13-18, 2006.

Dorres M, **Cowling K,** Goldenkranz S, Montano M. The importance of gender relations to public health and behavioral change interventions. Poster Presentation. Seattle, WA: University of Washington Undergraduate Research Symposium, May 19, 2006.

Montano M, **Cowling K**, Dorres M, Goldenkranz S. Effect of employee sense of efficacy on community interventions for HIV prevention. Poster Presentation. Seattle, WA: University of Washington Undergraduate Research Symposium, May 19, 2006.

PRESS

Cowling K. "Withdrawal from the TPP: What It Means for U.S. Food System." Blog Post. *Livable Future Blog* 6 February 2017. Online.

Cowling K. "Trade Agreements Could Stymie Nutrition Labeling." Blog Post. *Livable Future Blog* 3 February 2016. Online.

Cowling K. "The Sustainable Development Goals and Food Systems." Blog Post. *Livable Future Blog* 25 September 2015. Online.

Cowling K. "How the TPP Trade Deal Could Affect Food and Public Health." Blog Post. *Livable Future Blog* 8 July 2015. Online.

Greenberg A, **Cowling K**, Burns K. "Hopkins: Increase access to life-saving drugs." Editorial. *Baltimore Sun* 21 May 2015. Print.

Cowling K. "Universal and Sustainable Health Coverage." Exclusive Commentary. *Global Health NOW* 16 February 2015. Online.

HONORS

John C. Hume Doctoral Award, 2017
Johns Hopkins Center for a Livable Future-Lerner Fellowship, 2016, 2017
Health Resources and Services Administration Trainee Fellowship, 2015
Sir Arthur Newsholme Research/Teaching Assistantship, 2013-2017
Phi Beta Kappa Honor Society, 2007
University of Washington Undergraduate Achievement Award, 2003-04, 2004-05
Presidential Scholar candidate, 2003

PROFESSIONAL ACTIVITIES

American Public Health Association (APHA) Trade and Health Forum, *Member*
Bulletin of the World Health Organization, *Reviewer*
American Journal of Public Health, *Reviewer*

SKILLS

Software

STATA, R, ArcGIS, RefWorks, Zotero, Microsoft Office

Languages

Spanish	Intermediate proficiency
Norwegian	Intermediate proficiency
Hindi	Intermediate proficiency